Government of Canada | Gouvernement du Canada

Office of Critical Infrastructure Protection and Emergency Preparedness

Bureau de la protection des infrastructures essentielles et de la protection civile

Managing flood hazard and risk

Report of an independent expert panel

103-05064/

Acknowledgments

This publication has been prepared by:

**Office of Critical
Infrastructure Protection and
Emergency Preparedness**

2nd Floor, Jackson Bldg.
122 Bank St.
Ottawa, ON K1A 0W6
Tel: (613) 991-7035
Toll Free: 1-800-830-3118
Fax: (613) 998-9589
Email: communications@ocipep-bpiepc.gc.ca
Internet: www.ocipep-bpiepc.gc.ca

Authors:

Ashij Kumar
Ian Burton
David Etkin

This material is based upon work supported by the Directorate of Research and Development (DRD) in the Office of Critical Infrastructure Protection and Emergency Preparedness (OCIPEP), formerly Emergency Preparedness Canada, under Contract Reference No. 2000D010. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the Office of Critical Infrastructure Protection and Emergency Preparedness.

© 2001 Minister of Public Works and Government Services
Catalogue No.: D82-70/2002E-IN
ISBN: 0-662-32758-6

Panel of Experts

The Independent Expert Panel on Flood Mitigation would like to acknowledge the support and sponsorship of Emergency Preparedness Canada and the Adaptation and Impacts Research Group, Meteorological Service of Canada, in the research of this report. The report has been widely reviewed in draft form and we are especially grateful for written contributions, which were subsequently incorporated into the report, and comments of those that participated in this review (listed alphabetically by surname):

List of Reviewers

Brian Burrell and Patrick Tang
New Brunswick Dept. of the Environment
Fredericton, New Brunswick

James Choles
River Engineering Branch, Water Management Division, Natural Resources Service,
Alberta Environment
Edmonton, Alberta

R.A. Halliday
R. Halliday & Associates
Saskatoon, Saskatchewan

Steve Litke
Integrated Flood Hazard Management,
Fraser Basin Council
Vancouver, British Columbia

Raymond Perrier
Consultant
Vaudreuil-Dorion, Québec

Van Diem Hoang
Direction de l'hydraulique et hydrique,
Ministere de l'Environnement du Québec
Québec, Québec

Robert Picco
Water Resources Management Division,
Department of Environment & Labour,
Government of Newfoundland & Labrador
St. John's, Newfoundland

Toni Smith, Barbara Veale and Dwight Boyd
Grand River Conservation Authority
Cambridge, Ontario

John Theakston
Department of the Environment
Halifax, Nova Scotia

Steven D. Topping
Water Resources Branch
Winnipeg, Manitoba

Phil Wintemute
Emergency Measures Branch,
Yukon Government
Whitehorse, Yukon

List of Lead Authors

Ian Burton
Adaptation and Impacts Research Group,
Meteorological Service of Canada
Downsview, Ontario

David Etkin
Adaptation and Impacts Research Group,
Meteorological Service of Canada
Located at Institute for Environmental Studies,
University of Toronto
Toronto, Ontario

Ashij Kumar
Adaptation and Impacts Research Group,
Meteorological Service of Canada
Downsview, Ontario

C. Emdad Haque
Brandon University, Dept. of Geography,
Environment & Resource Development
Brandon, Manitoba

Frank Millerd
School of Business and Economics,
Wilfrid Laurier University
Waterloo, Ontario

Alan Pang
Institute for Catastrophic Loss Reduction
Toronto, Ontario

Dave Peters
Consultant
Manotick, Ontario

List of Contributing Authors

Peter Anderson
School of Communication, Telematics
Research Lab, Simon Fraser University
Burnaby, British Columbia

Greg Brooks
Geological Survey of Canada,
Terrain Sciences Division
Ottawa, Ontario

Don Greer
Ministry of Natural Resources
Peterborough, Ontario

Dan Shrubsole
Department of Geography,
University of Western Ontario
London, Ontario

Slobodan Simonovic
Natural Resources Institute,
University of Manitoba
Winnipeg, Manitoba

Chris Tucker
Emergency Preparedness Canada,
Office of the Senior Scientific Advisor
Ottawa, Ontario

Executive Summary

Floods have gained attention in Canada as the number one natural disaster in terms of cumulative property damages and losses. This attention has recently grown due to various factors: the Saguenay region (1996) and the Red River valley (1997) flood disasters; the probable increase of this hazard due to climatic variations and change; land use changes; and the present situation of floodplain management, which is currently at a significant crossroads.

The Independent Expert Panel on Flood Mitigation was selected and assembled by the Chair, Ian Burton, acting on recommendation from the sponsoring organizations and after consultation with a number of leading experts. The Expert Panel met December 15th to 16th, 1999, in Hull, Québec, to review a draft outline of the report which had been prepared in advance and to decide on the structure and main directions of the report. The report begins with a general discussion of the progression of flood management approaches, from local and provincial responsibility to greater federal involvement in flood protection infrastructure, floodplain land use regulations, disaster assistance, and now more recently has come full circle with greater responsibility on local individuals and municipalities with the termination of the Flood Damage Reduction Program (FDRP). Next the report describes the growing flood risk and factors that have contributed to increased costs of flood damages. Then an overview of past achievements and actions for flood control and reduction, along with the lessons learned from these activities, are presented. This involves a discussion of flood protection infrastructure, the role of local level organizations such as Ontario conservation authorities, federal disaster assistance, Canadian Water Acts, and finally assessments of the FDRP. The report concludes with recommendations, which include steps to reduce flood damage potential, areas of further research, and elements of institutions and policy environments to be strengthened or developed in order to deal with flood hazards. A summary of these recommendations follows.

Summary of Recommendations

The Editors have reviewed the deliberations and suggestions developed at the December 1999 meeting. These have been extensively revised through communications with the Panel Members, while taking account the comments from 14 reviewers from all regions of Canada.

While every effort was made to solicit and include expert judgment from all regions of Canada, some members of the Panel feel that the report does not sufficiently reflect the diverse situations of flood risk management across the country. Further work may be required to ensure that the assessments and recommendations agreed by the Panel have not inadvertently overlooked some important evidence or experience.

There is no doubt that the main consensus of the Panel and the reviewers is that a comprehensive program for floodplain management and flood hazard mitigation is

required under a national cost-shared arrangement. This program should comprise of the actions listed in the following 15 recommendations. These recommendations have been grouped into the following three areas: reduction of flood damage potential, research, and institutional and policy environments.

Reducing Flood Damage and Potential

- Flood risk maps should be kept accurate and up to date.

There is widespread concern that flood risk maps are becoming outdated due to changes in land use, bridge construction, river channel constriction, and climate variability and change. There are also some potential liability issues which depend upon accurate maps. Responsibility for flood risk mapping was previously shared by the federal and provincial governments, but is now solely in the hands of the provincial governments.

- The role of Geographic Information Systems (GIS) and new technology in flood risk management should be further expanded and strengthened.

The application of GIS in flood hazard management and the development of the Natural Hazard Electronic Map and Assessment Tools Information System (NHEMATIS), by Emergency Preparedness Canada, have demonstrated the effectiveness of new technologies. These tools should be increasingly applied to flood risk assessment, long-term floodplain management, and updating flood risk maps.

- Flood warning and forecasting should remain an important component of flood hazard mitigation, and in conjunction, hydrometric data collection should be strengthened rather than reduced.

Real-time hydrological measurement networks should be adequately maintained or expanded to provide timely and accurate data for numerical flood forecast models and subsequent warnings. While some provinces' rivers are adequately being monitored others are lacking sufficient monitoring (especially for smaller rivers and streams), which should be addressed through an expansion of real-time monitoring stations for these areas.

- Strengthen monitoring and enforcement of policies and programs in floodplain land use associated with flood risk mapping.

There is a concern that expansion of property, both residential and commercial, is taking place in high risk floodplain areas, and the Panel would like to see better monitoring and enforcement to reduce or prevent the growth of flood damage potential.

- Study the potential use of economic instruments for flood risk management such as user taxes, flood insurance, and the user pay principle.

There is a concern that flood risk management has relied too heavily on regulatory approaches, which have not always been implemented effectively. The Panel considered that other more market driven approaches should be explored, which would increase choice and would help protect public agencies from growing flood damage compensation payments. It is recognized that these methods require careful evaluation prior to any implementation.

- Expand the responsible community to include the private sector.

The Panel considered that more could be done to enlarge the community involved in flood risk management. In particular the banking, real estate development, and insurance industries should become more actively involved in flood hazard mitigation. Awareness of flood risk could be increased by mandatory disclosure of flood risk information from maps, and through mortgages and property deeds, and through transparent clauses in insurance contracts.

- Strengthen public education and build greater awareness at the community level.

The Panel felt that policies and measures to reduce flood damages are unlikely to succeed in the absence of greater awareness among members of the public, community leaders, decision makers, and local political leaders. Communications facilities, and public participation programs are readily available or could be quickly created to facilitate this.

- Build resilient communities.

There is opportunity to strengthen community resilience to floods where it is most lacking by encouraging and facilitating building relocation, flood proofing, and by investments that will strengthen economic, human and social capacity at the community level.

Research

- Improve the knowledge of impacts and the quality of data on flood losses.

The development of flood risk management is hampered by lack of knowledge of socio-economic and environmental impacts and consistent data on flood losses. While information is available on the level of compensation payments, the actual amount of losses is only estimated on the basis of unsystematic, anecdotal, and non-comparable information collected in an ad hoc manner after each major flood. Data on minor or more moderate floods is often lacking. Systematic flood loss reporting into a national database accessible on the World Wide Web would be a valuable policymaking and assessment tool.

- Expand post-audits of flood disasters to improve understanding of the effectiveness of mitigation actions.

While the effectiveness of some past decisions has been widely applauded, there is in fact little post-audit assessment of past mitigation efforts. More research would be helpful using benefit-cost analysis, or studies considering positive and negative actions in guiding decision makers at all levels towards effective flood hazard reduction.

- Study risk-taking behaviour and risk mitigation and response measures taken by high flood risk communities and individuals.

Little is known about how flood risks are perceived in relation to other risks, and how the individual, the flood risk level, and the community interests combine to explain risk-taking behaviour. There is also little research on what people are willing to do in order to lessen the risk of flood damages and losses.

Institutional and Policy Environments

The Panel supports recent proposals that have been made to create a comprehensive flood mitigation program or policy. The form that such a program might take is beyond the scope of the Panel, but it is clear that such a program would require strengthening of existing effective programs and policies, and institutional innovations involving new mandates at the federal level and renewed cooperation arrangements with the provincial governments.

- A comprehensive flood mitigation program should incorporate aspects of an integrated ecosystems approach.

Managing floods using this holistic approach takes into consideration the complex relationships between environment, society and economic systems in the management of flood hazards. Floodplains would be managed in the best interest of both the natural and human environment.

- Strengthen individual, community, and municipal responsibility and capacity in floodplain management and flood hazard mitigation.

There is a growing recognition that responsible decision-making with respect to flood risk management should be taken at a local level and move to higher levels of government only when local capacity is exceeded. It is in the nature of flood problems that provincial and federal government assistance will always be required, but such assistance should be carefully designed to support and not undermine local authority and leadership. The effectiveness of various cooperative arrangements in managing flood risk should be carefully reconsidered.

- Revise the Disaster Financial Assistance Arrangements program.

There is evidence that the disaster financial assistance program is not working as well as it could. The Panel suggests that it be reviewed and that change to be considered include a provision that a specific proportion of the funds (say 15%) should be earmarked for mitigation actions. Consideration should also be given to withholding disaster assistance from new developments that are constructed in high flood risk zones, unless additional precautions have been taken such as flood proofing or building elevation. There might also be a limit to the number of times compensation is paid for flood damage to the same property.

- Give careful consideration to the National Mitigation Strategy proposed by the Institute for Catastrophic Loss Reduction.

While the Panel does not wish to endorse the specific details of the proposed National mitigation Strategy, it makes good sense to consider all possible ways that can be employed to create a culture of preparedness and damage mitigation.

Table of Contents

Acknowledgments ii

Panel of Experts iii

Executive Summary v

Summary of Recommendations v
Reducing Flood Damage and Potential vi
Research vii
Institutional and Policy Environments viii

1.0 Protecting from Unacceptable Flood Losses 1

2.0 Growing Flood Risk and Sustainability 2

3.0 Achievements and Lessons Learned 7

3.1 Structural Flood Controls 7
3.1.1 Necessity of Flood Protection Infrastructure 7
3.1.2 Issues Regarding Structural Works 8
3.2 Ontario Conservation Authorities 9
3.3 Disaster Assistance 11
3.4 Water Policies, Acts and Programs 15
3.5 Post-Audits of the Flood Damage Reduction Program 18
3.5.1 Issues of Designation and Regulation 18
3.5.2 Comparative Analyses 19
3.5.3 Future Flood Damage Reduction Studies 21
3.5.4 Future DFAA Costs 21

4.0 Summary of Panel Deliberations 22

4.1 Reducing Flood Damage and Potential 22
4.1.1 Floodplain Mapping 22
4.1.2 Geographic Information System and New Technology 23
4.1.3 Flood Forecasting and Warning 25
4.1.4 Monitoring and Enforcement 26
4.1.5 Economic Instruments 26
4.1.6 Co-operative Alliances 28
4.1.7 Information and Education 29
4.1.8 Resilient Communities 29
4.2 Research 30
4.2.1 Flood Impacts 30
4.2.2 Assessments of Programs and Policies 31
4.2.3 Risk-Taking and First Responders' Behaviour 32
4.3 Institutional and Policy Environments 32
4.3.1 Integrated Ecosystem Approach 33
4.3.2 Responsibility / Liability and Involvement 34
4.3.3 Redefining Disaster Assistance 35
4.3.4 National Mitigation Strategy 36

Appendix A – Independent Expert Panel Members **A-1**
Appendix B – List of Participants from Flood Mitigation Workshop **B-1**
Appendix C – Workshop Agenda from Flood Mitigation Workshop **C-1**
Appendix D – References **D-1**

1.0 Protecting from Unacceptable Flood Losses

From the earliest days of European exploration and settlement, Canada's rivers served as main highways and arteries of transport. This history led to the establishment of the first settlements along rivers and on lakeshores. Many of these settlements have now grown into cities or substantial communities located on lands subject to periodic flooding. While flood problems may not be as disastrous as in other countries, they do exist along many rivers and coastlines across Canada. They are most commonly due to snowmelt, rain, ice jams, and coastal storms alone or in combination. Potential flood disasters, however, may be kept within bounds by effective action as seen through the evolution of flood management approaches.

Historically, floods were regarded as a local problem for communities themselves to deal with. During the 20th century, senior governments began to accept more responsibility due to: the growth of cities; the development of new and more costly engineering technology; the rise of the welfare state; and the growth of the idea that government was responsible for the protection of citizens from perils of all kinds. In the early decades of the century the emphasis was on flood control engineering. By the 1950s and 1960s, government intervention extended to improve forecasting and warning systems and then the regulation of floodplain land use and development. The flood hazard-mapping program, entitled the Flood Damage Reduction Program (FDRP), was initiated by the federal government to provide the scientific and technical basis for hazard zone definition and to help ensure that legislation for the restriction of development would be upheld in the courts. The evolution from a heavy reliance on engineering works to a greater mix of structural and non-structural solutions has contributed to Canada's effective flood policy and response.

Despite the accepted value of these policies and projects to reduce flood damages, a mood of scepticism within the federal government gained ground towards the end of the century. Fuelled by the fact that floodplain development restrictions were difficult to apply with an even hand, certain unhappiness developed that some regions were not applying the policies as effectively as others. It also became clear that despite the policies, flood damage compensation and disaster assistance claims on the federal government were growing, and according to some, growing in a rather uneven way. This included the fact that the costs of managing the FDRP were being accrued in one department while the benefits, through less disaster relief, were in another. In the mid 1990s, these concerns, coupled with a widely recognized need for greater financial stringency in government programs, led to the termination of federal involvement in the Flood Damage Reduction Program.

The need for an independent look at the flood problem in Canada today arose from various factors that threaten to increase flood losses. Apart from increasingly urbanized populations with greater wealth, two major changes have occurred which threaten to jeopardize this enviable record. First, the relatively stable hydrological regime, which Canada has enjoyed, is now subject to change due to climatic variations and change. While some scientific uncertainty remains, the circumstantial evidence and applicable theory both point to an increase in the frequency and magnitude of extreme events. To say the least there is a new risk of potentially considerable proportions. This will develop in the decades to come, but a precautionary attitude seems appropriate now. Second, the federal government has recently cancelled its participation with the

federal-provincial Flood Damage Reduction Program of flood hazard mapping and floodplain designation. While it is true that the majority of occupied urban floodplains in Canada have been mapped and flood zones designated, these designated boundaries are not stable. New construction, new bridges and other constriction points, land clearance and deforestation, as well as changes in hydrological regime related to the climate system, all result in changes to the delineation of flood hazard zones. Maps therefore must be kept up to date. With the withdrawal of the federal government, the program is not likely to be maintained to the same high standard of reliability (or even maintained at all in some Provinces). The extra burden placed upon provinces and municipalities may lead to lesser attention and ultimately greater risks. In addition, recent disaster events, such as the Saguenay floods of 1996 and the Red River flood of 1997, suggest there this is no time for complacency.

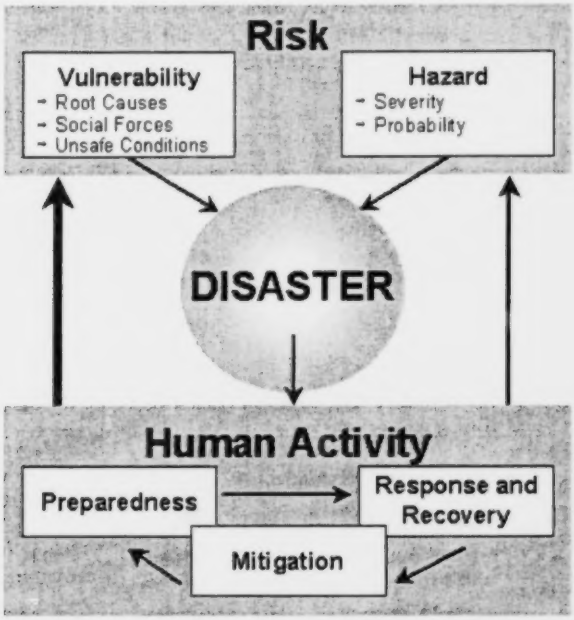
For these reasons, it is time to reassess the flood hazard situation and to consider carefully what now needs to be done to continue to protect Canadians from unacceptable flood losses in the future, which is what this report attempts to do. The Chair, Ian Burton, assembled an Independent Expert Panel under the recommendations of Emergency Preparedness Canada and Environment Canada to accomplish this. It is important to be clear about the scope of this report. It is concerned with floods as they occur along rivers and watercourses, on the shores of lakes and on the seacoasts. For both practicalities of report preparation and potential use of results the subject matter of the report focuses on floods in this sense. However, other related hazards such as bank erosion from floodwaters, the instability of slopes from undercutting, and solifluction and the like can be an integral part of flood damages. While these are not directly discussed in their own context their importance should not be overlooked.

This report begins with a description of the growing flood risk in Canada. A discussion of the achievements and lessons learned from key activities and aspects such as structural flood control, the role of conservation authorities in Ontario, federal disaster assistance, water policies, acts and programs are then presented. The evolutionary view of policies and practices for dealing with floods provides a basis for a series of recommendations and proposals, which were developed by Working Groups within the Independent Expert Panel, which are then presented.

2.0 Growing Flood Risk and Sustainability

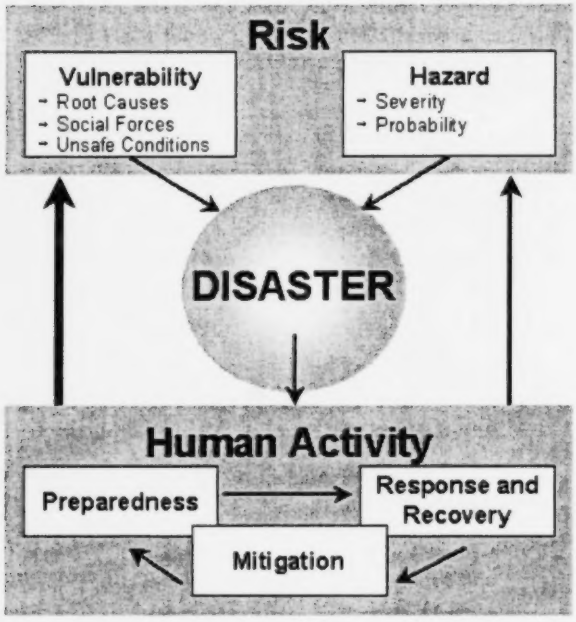
Flood risk and the subsequent damages from flood events are due to various factors: weather or climate, involving rates and amounts of precipitation, depth of snowpacks etc.; the vulnerability of infrastructure and populations; and economic variability and trends, such as the commercial and industrial development of an area. Figure 2.1 generally depicts disaster risk. In this sense, *risk* is defined as some product of the probability of the physical hazard with the potential damage to the social fabric. Flood risk will vary as a result of climate variability and trends, and social variability and trends. Society responds to a disaster through three overlapping activities: 'Response and Recovery', 'Mitigation' and 'Preparedness' (bottom box of Figure 2.1). These activities alter future vulnerability (and therefore the construct of future disasters); reducing risks if they are done wisely, or not if they are done otherwise. The relationships shown in Figure 2.1 depict a dynamic, interactive system, composed of both natural and social forces.

Figure 2.1 Disaster Adaptation Cycle. A disaster occurs when social vulnerability is triggered by some event. If the trigger is of natural origin, then the disaster is called a 'natural disaster'. The disaster typically triggers a cycle of human response including response and recovery, mitigation and preparedness. This response can alter our vulnerability and thereby influence future disasters.



Data from Emergency Preparedness Canada (EPC) and the insurance industry show a growing trend for flood related disaster costs (Figure 2.2). There have been two notable Canadian flood disasters in recent years, which include the Saguenay 1996 floods and the 1997 Red River flood. Table I presents the costs of these floods, which may still be preliminary and not representative of total costs. The Red River flood, which was a disaster that was luckily averted, was relatively less costly than the floods in the Saguenay region. It has been estimated that had the structural defences protecting Winnipeg failed, the flood cost of $67 million in Winnipeg alone would have reached $761 million.

Figure 2.1 Disaster Adaptation Cycle. A disaster occurs when social vulnerability is triggered by some event. If the trigger is of natural origin, then the disaster is called a 'natural disaster'. The disaster typically triggers a cycle of human response including response and recovery, mitigation and preparedness. This response can alter our vulnerability and thereby influence future disasters.



Data from Emergency Preparedness Canada (EPC) and the insurance industry show a growing trend for flood related disaster costs (Figure 2.2). There have been two notable Canadian flood disasters in recent years, which include the Saguenay 1996 floods and the 1997 Red River flood. Table I presents the costs of these floods, which may still be preliminary and not representative of total costs. The Red River flood, which was a disaster that was luckily averted, was relatively less costly than the floods in the Saguenay region. It has been estimated that had the structural defences protecting Winnipeg failed, the flood cost of $67 million in Winnipeg alone would have reached $761 million.

Figure 2.2 Flood damage payments from Disaster Financial Assistance Arrangements (DFAA) and the insurance industry along with Canada's population since 1975. Costs standardized to 1999 dollars and show both federal and provincial/territorial contributions. Note that these figures do not include costs of provincial assistance to sub-DFAA threshold events (i.e., less than $1 per capita provincial population) *(Shrubsole, 2000).*

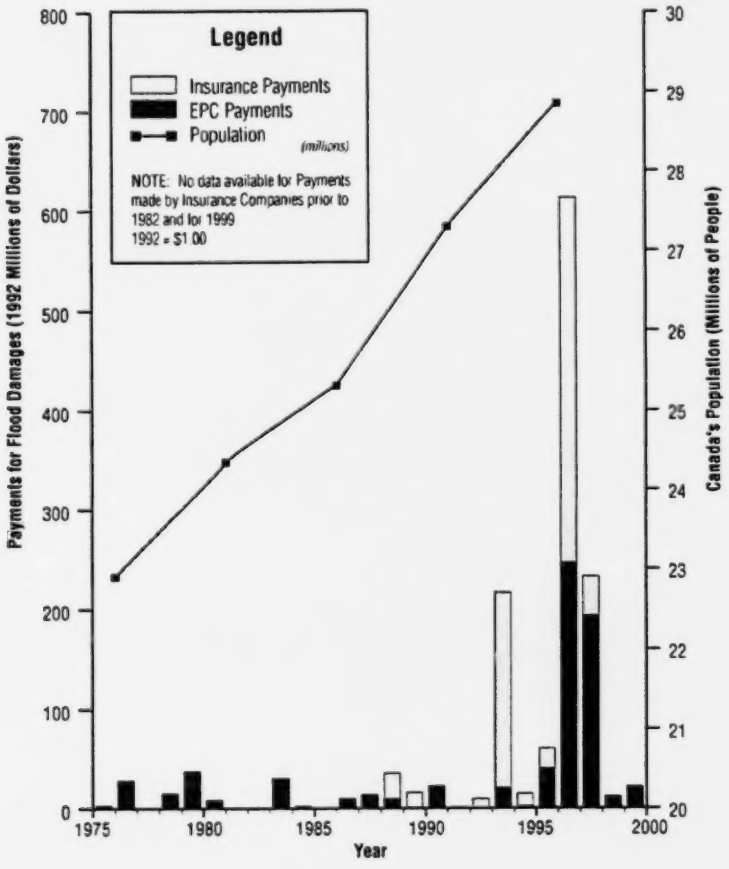


Table I Costs of the 1996 Saguenay and 1997 Red River Floods

Cost Item	Saguenay 1996 floods (millions of 1999 dollars)	Red River 1997 flood (millions of 1999 dollars)
Federal DFAA share	$175	$183
Provincial DFAA share	$31	$20
Federal department/program[1]	$109	$172
Provincial department/ programs[2]	*N/A*	*N/A*
Municipal / local government costs	$1,031	$305
Public utility costs	*N/A*	*N/A*
Insurance payouts	$218	$102
NGO payments	$33	$33
Total Costs	**$1,597**	**$815**

[1] Costs paid by federal programs for disasters.
[2] Provincial costs incurred for the disaster.
(Emergency Preparedness Canada, 2000)

In a society that has become increasingly technological and knowledgeable, one wonders why flood damage costs have been increasing. Whether or not they are sustainable and whether the long-term benefits gained from the use of floodplains are greater than long-term costs? Table II presents a number of factors that have contributed to the increased risk of flood disasters resulting in their increased costs.

Table II Factors contributing to the increased costs of floods

Contributing Factor	Comments
Increased wealth	• Canadians are wealthier than the past. They have more goods (which are often costlier) to be potentially damaged, increasing overall disaster costs. • This does not necessarily mean that disasters are worse per se. A wealthier society may be better able to recover from extreme events, while less costly disasters can be more disastrous to poor populations.
Growing urbanized populations	• Canadian populations have grown, and become increasingly urbanized. • Urban flooding is exacerbated by development that reduces ground infiltration and increases streamflow.
False perception of safety	• Perceptions of safety as a result of mitigation may permit undue development in risky areas, out of proportion to the flood threat, thereby increasing vulnerability to extreme events. • Some studies show that there has been an inordinate amount of development in floodplains in some regions of Québec, though this trend is certainly not universal (Roy *et al.*, 1997; Forget *et al.*, 1999). • Development near or in a floodplain may not necessarily be bad or unsustainable (though this is sometimes the case) if it is well thought out with a clear understanding of the flood hazard.
Flood protection works	• Flood protection works may attract development on the floodplain thereby increasing potential damages when the infrastructure fail to contain or control flood waters. • Greater dependency on flood protection infrastructure and technology may result in greater vulnerability to extreme events, rare though they may be.
Perils of short-term thinking	• Where short-term thinking prevails, high magnitude, infrequent events receive insufficient attention leading to the acceptance of greater flood risk.
Aging or old infrastructure	• Aging infrastructure can increase flood risk. Dams, for example, which are also used in flood control pose significant hazards in the United States and Ontario, Canada, if not maintained (American Society of Civil Engineers, 1998; Tiner, 1998). • Dam failures are often caused by inadequate spillway capacities (common to older dams), which releases water in heavy rains when water runs over the top (American Society of Civil Engineers, 1998).
Poorly defined flood risk or lack of enforcement	• Flood risk areas adjacent to cities can be poorly defined or enforcement not thoroughly carried out, putting rural property at greater threat from flood damages. • This has been the case in rural Manitoba (International Joint Commission, 1997) and has also been noted in Saskatchewan.

If the rising costs of natural disasters seen in recent years in Canada and globally since the 1980s represent a trend, then it can be well argued that these costs are not sustainable. However, any

Table I Costs of the 1996 Saguenay and 1997 Red River Floods

Cost Item	**Saguenay 1996 floods (millions of 1999 dollars)**	**Red River 1997 flood (millions of 1999 dollars)**
Federal DFAA share	$175	$183
Provincial DFAA share	$31	$20
Federal department/program[1]	$109	$172
Provincial department/ programs[2]	*N/A*	*N/A*
Municipal / local government costs	$1,031	$305
Public utility costs	*N/A*	*N/A*
Insurance payouts	$218	$102
NGO payments	$33	$33
Total Costs	**$1,597**	**$815**

[1] *Costs paid by federal programs for disasters.*
[2] *Provincial costs incurred for the disaster.*
(Emergency Preparedness Canada, 2000)

In a society that has become increasingly technological and knowledgeable, one wonders why flood damage costs have been increasing. Whether or not they are sustainable and whether the long-term benefits gained from the use of floodplains are greater than long-term costs? Table II presents a number of factors that have contributed to the increased risk of flood disasters resulting in their increased costs.

Table II Factors contributing to the increased costs of floods

Contributing Factor	Comments
Increased wealth	• Canadians are wealthier than the past. They have more goods (which are often costlier) to be potentially damaged, increasing overall disaster costs. • This does not necessarily mean that disasters are worse per se. A wealthier society may be better able to recover from extreme events, while less costly disasters can be more disastrous to poor populations.
Growing urbanized populations	• Canadian populations have grown, and become increasingly urbanized. • Urban flooding is exacerbated by development that reduces ground infiltration and increases streamflow.
False perception of safety	• Perceptions of safety as a result of mitigation may permit undue development in risky areas, out of proportion to the flood threat, thereby increasing vulnerability to extreme events. • Some studies show that there has been an inordinate amount of development in floodplains in some regions of Québec, though this trend is certainly not universal (Roy *et al.*, 1997; Forget *et al.*, 1999). • Development near or in a floodplain may not necessarily be bad or unsustainable (though this is sometimes the case) if it is well thought out with a clear understanding of the flood hazard.
Flood protection works	• Flood protection works may attract development on the floodplain thereby increasing potential damages when the infrastructure fail to contain or control flood waters. • Greater dependency on flood protection infrastructure and technology may result in greater vulnerability to extreme events, rare though they may be.
Perils of short-term thinking	• Where short-term thinking prevails, high magnitude, infrequent events receive insufficient attention leading to the acceptance of greater flood risk.
Aging or old infrastructure	• Aging infrastructure can increase flood risk. Dams, for example, which are also used in flood control pose significant hazards in the United States and Ontario, Canada, if not maintained (American Society of Civil Engineers, 1998; Tiner, 1998). • Dam failures are often caused by inadequate spillway capacities (common to older dams), which releases water in heavy rains when water runs over the top (American Society of Civil Engineers, 1998).
Poorly defined flood risk or lack of enforcement	• Flood risk areas adjacent to cities can be poorly defined or enforcement not thoroughly carried out, putting rural property at greater threat from flood damages. • This has been the case in rural Manitoba (International Joint Commission, 1997) and has also been noted in Saskatchewan.

If the rising costs of natural disasters seen in recent years in Canada and globally since the 1980s represent a trend, then it can be well argued that these costs are not sustainable. However, any

trends resulting from human decisions are in theory reversible, and through the use of effective mitigation strategies can be halted or reversed. It must be noted that climate change may play a very important role in altering flood risk, and therefore future flood damages. An intensified hydrological cycle and a greater proportion of precipitation coming from convective storms seem likely to increase future flooding. The rate and amount of change is uncertain at this time, and therefore it is not exactly clear what the future impacts will be, though they may well be very significant.

3.0 Achievements and Lessons Learned

This section presents an overview of the actions taken to control and reduce floods throughout Canada. It also highlights some of the important lessons learned from these activities. It involves a discussion of structural works, the role of conservation authorities in Ontario, federal disaster assistance, Canadian water policies, acts and programs, and assessments of the federal Flood Damage Reduction Program.

3.1 Structural Flood Controls

Up until the late 1960s, engineering structures were used to control and regulate hydraulic systems and were the preferred method of addressing flood problems (de Loë, Forthcoming). While these structures are quite costly, they are often necessary and the only means of reducing or containing flood waters. In addition, they have played an important role in curbing even larger disaster costs.

3.1.1 Necessity of Flood Protection Infrastructure

The Red River Valley in Manitoba is an excellent example of where the simple avoidance of flood prone areas is difficult to accomplish through land use planning because of the wide extent of the flood zone. The 100-year floodplain south of Winnipeg extends 40 km in width in some places and comprises some of the richest agricultural land in prairie Canada. Prohibiting the occupation of the floodplain is not feasible. The preferred approach has been to protect valley communities by ring dikes and encouraging moving, raising or diking of farmsteads to reduce the risk of damage. To protect Winnipeg there has been a large-scale investment in structural solutions following the Red River flood disaster of 1950. This included the construction of three major structures, the Red River Floodway, the Portage Diversion and Shellmouth Dam, at costs of $63.2 million, $17.5 million and $11.5 million, respectively, which was shared by the federal and provincial governments at a 60%-40% split (Topping, 1997, as cited in Haque, Forthcoming). However, the benefits of these structures have been found to vastly outweigh the high costs of construction. It was estimated by a Manitoba Water Resources official that without the Floodway and related works, the natural peak stage at Winnipeg of the 1974 flood would have approached the level of the 1950 flood level, which would have caused total damages of $200 million (Fisheries and Environment Canada, 1976). Park (1997) states that the 1997 Red River flood was not as catastrophic as the flood of 1950, despite an approximately 50% greater discharge level, at least partly due to the flood control structures put into place after 1950. The general consensus is that these structural works have prevented flood-estimated damages as high as $6 billion since the mid-

1960s (Morris-Oswald *et al.*, 1998). Flood control infrastructure can therefore be very effective in mitigating damage from flooding.

3.1.2 Issues Regarding Structural Works

While structural solutions provide a level of flood reduction and protection there are issues associated with heavily relying on these measures, such as their false sense of security, the question of their long-term value, and costs associated with their operation and maintenance. In addition, these tradeoffs may become more pronounced in the future as flood risk increases due to climatic variations and change, vulnerability of infrastructure and populations, and economic variability and trends.

Relying on structural solutions to reduce or control floods may offer a false sense of security. Regions protected by infrastructure may not be inclined to seek other solutions since there may be a prevalent belief that the engineering works will protect from all flood events. The consequence of this may be continued or increased development in the floodplain behind flood control structures. This has been seen in New Brunswick where development behind an aboideaux (tidal control dams and gates) in Marsh Creek, St. John, had been encouraged in the past (Cardy, 1976). Structural flood control measures have also more recently been identified in the Red River Valley, Manitoba, and areas of Québec (Morris-Oswald *et al.*, 1998; Forget *et al.*, 1999). Unfortunately, flood protection infrastructure cannot protect against all floods since they are built to accommodate floodwaters up to a specific level, or the *design flood,* defined as the extreme flood event used in the design of the specific flood protection infrastructure. Dam or dike failure can potentially exacerbate flood damages, human injury, and loss of life, due to the high flow velocities and limited ability for warning and evacuation in the event of a structural failure. Breaching of a dike or dam results in low-lying areas being quickly inundated compared to comparably slower floodwaters which rise across the floodplain. During the 1996 Saguenay floods, in Québec, discharge levels of rivers exceeded the designed and, in some cases, the spilling capacity of a number of dams resulting in overtopping of dams and dikes (Grescoe, 1997). In addition, the current design capacities of flood protection infrastructure may not factor in the magnitude of flooding that may occur from climate variations or changes in the basin due to development. Exacerbating the false sense of security is the fact that various reports have commented on the concern over the current and future state of flood protection infrastructure (e.g., CSTGB, 1997; Grescoe, 1997; Tiner, 1998; Forget *et al.*, 1999).

The continued reliance upon infrastructure also raises questions about its long-term value and the degree of reliance that should be placed on it. Relying solely on or placing greater emphasis on flood infrastructure does not promote *flood resiliency*, defined as a community's ability to quickly 'bounce back' after a flood event without permanent, intolerable damage or disruption, or large amounts of outside assistance (Natural Hazards Center, University of Colorado and Disaster Research Institute, University of Manitoba, 1999). Significant ecosystem impacts may also result from structural works such as: fragmentation of streams, wetlands and side channels from rivers; impediment of fish migration by flood gates or pump stations; and the simplification and degradation of habitat features by riverbank armouring (i.e., erosion control) and diking. In addition, the inappropriate operation and management of flood infrastructure may exacerbate flooding and damages, which has been identified across Canada:

- In Manitoba, operations of the Red River floodway control gates may cause elevated water level upstream resulting in an accentuation of flood damages (Haque, Forthcoming).

- The presence of numerous dams and other control structures (approximately 2,000 dams and dikes with minimal environmental and technological controls in the Québec region) and their improper management resulted in conflicting decisions that exacerbated flooding during the Saguenay floods of 1996 (CSTGB, 1997; Grescoe, 1997).

- Ontario's many dams are not necessarily managed for the good of the whole watershed (Tiner, 1998).

In addition, flood protection works require ongoing inspection, maintenance, and rehabilitation over time, which can be very costly for the responsible authority. If adequate financing of maintenance and rehabilitation is not available, these structures may deteriorate. Many local government authorities have identified a need for senior government financial assistance to aid in major capital works such as dike rehabilitation. Municipalities may not be very eager to assume these sorts of costs alone. Without maintenance of these structures flooding may be exacerbated. For instance, for rivers with long-lasting freshets[1] (such as the two to three weeks for the Fraser River, British Columbia) and in areas of sandy soils, significant volumes of water may seep through or under the dike system due to water pressure if there is inadequate drainage and pumping. The problem of an aging infrastructure associated with a reduction in financial commitment from senior governments has been identified in Ontario as a threat to flood control (Tiner, 1998).

3.2 Ontario Conservation Authorities

Early non-structural initiatives involving floodplain management through mapping and land-use restriction occurred in Ontario well before the emergence of the Flood Damage Reduction Program in 1975. The Conservation Authorities Act, passed in 1946, was accompanied by a branch created in the Department of Planning and Development to survey watersheds and make recommendations concerning flood control measures in areas where municipalities formed conservation authorities. After Hurricane Hazel struck Toronto in 1954 floodplain management programs and policies arose, which included:

- a policy of zoning for many municipalities to prevent serious flood damage and use all means to minimize flooding impacts;
- the use of the Conservation Authorities Act regarding fill regulation by many municipalities to control construction in the floodplain;
- provincial support to municipalities and conservation authorities by providing enabling legislation, leadership, technical assistance, construction and mapping;
- federal support in the aid in construction of reservoirs and channels; and
- an emphasis on floodplain land acquisition, flood warning and disaster relief (Giles, 1976; Mitchell and Shrubsole, 1992).

---

[1] River and stream annual peak flows, which often result in flooding, that are caused by snow and ice melt in the spring or early summer in mountainous regions releasing large quantities of water (Andrews, 1993).

The formation of conservation authorities in Ontario has played an important role in the early initiative of reducing flood damage through limiting floodplain development. It is one example of the importance of local level organizations. Municipalities took responsibility for regulating and managing floodplain development armed with a set of legislation, mainly The Planning Act and The Conservation Authorities Act. More than 75% of development in urban areas occurred prior the establishment of these floodplain management strategies and there has been limited encroachment of new development in floodplains after the involvement of conservation authorities (Ministry of Natural Resources, 1977). A review of numerous reports, by Shrubsole (1996), has commented on the success of conservation authorities. Over the past 50 years, conservation authorities with government, non-government and private group partnerships have successfully facilitated, co-ordinated and managed a wide range of watershed resource programs (Table III - Accomplishments) that have successfully reduced flood damages and hazards (Veale *et al.*, 1997). However, there have also been issues and shortfalls that should be addressed or acknowledged in order to strengthen effective floodplain management by conservation authorities (Table III - Issues or Shortfalls).

Table III Accomplishments and Shortfalls of Ontario Conservation Authorities

Accomplishments	Issues or Shortfalls
• Maintain and operate real time Hydrologic Monitoring Network (in cooperation with the province and federal government). • Carry out flood forecasting and warning. • Operate and maintain flood control reservoirs and construct and maintain flood protection works (channels, dykes). • Work with municipalities to control development near major riverbanks and where necessary aid in stabilizing major river bank slopes. • Regulation of construction and filling within flood plains and wetlands. • Planning, reviewing and advising municipalities under the Planning Act to minimize flood impacts. • Define flood hazard by flood risk mapping. • Carry out a program of information and education on flood management. • Carry out a program of reforestation to aid in reducing flood flows and soil erosion. • Maintain preparedness to act during periods of floods, and maintain local knowledge of watershed and flooding issues.	• Some Authorities do not carry out adequate monitoring of flood plain development and adequate enforcement of the regulations. • Prosecution of violations not always supported by the courts. • Because weakness exists in the present Conservation Authorities Act, regulations have not controlled all flood plain development or addressed all policy objectives. The new revised Act will address many of these weaknesses. New generic regulations to implement the revised Act will be ready by the end of 2001. • Differences exist among Conservation Authorities' ability and expertise to carry out flood plain management. • Not all areas have a Conservation Authority to implement a flood management program. • Reductions in provincial funding have reduced the Authorities' ability to maintain flood infrastructure and the flood plain mapping program.

(Smith et al., 2000)

3.3 Disaster Assistance

While provinces and their municipalities take primary responsibility for dealing with natural disasters such as floods, it has been the general practice of the federal government to financially assist the provinces when requested (Fisheries and Environment Canada, 1976). Since 1970, Emergency Preparedness Canada has been providing federal disaster assistance through Disaster Financial Assistance Arrangements (DFAA). Compensation given to provinces for disasters is based on a per-capita cost-sharing formula (Table IV). There are also DFAA Guidelines that outline the eligible disaster-related costs covered by the federal government. Specific examples of provincial/territorial expenditures that are eligible and those that are not eligible for federal cost-sharing are provided by Emergency Preparedness Canada (1999), but generally include such activities as restoring public works to their pre-disaster condition and replacing and repairing basic, essential personal property of individuals, small businesses and farmsteads. The DFAA

were an improvement over previous federal assistance that was negotiated on an ad hoc, disaster-by-disaster basis (Fisheries and Environment Canada, 1976).

Table IV Cost-sharing formula outlining federal disaster financial assistance

Provincial Expenditure Eligible for Cost-Sharing	Provincial / Territorial Share (%)	Federal Share (%)
First $1 per capita	100	0
Next $2 per capita	50	50
Next $2 per capita	25	75
Remainder	10	90

(Adapted from Emergency Preparedness Canada, 1999)

The DFAA operates on a sliding scale based on population and damages. The increasing relationship between damages and assistance results in higher flood damages receiving greater federal assistance. As well, despite the policy that disaster assistance is to be withheld for any development built after designation (which excludes floodproofed development in the flood fringe) some evidence indicating the contradictory exists. For example, federal disaster assistance has not been withheld in high flood risk areas of the lower Fraser River, British Columbia, where development has increased the number of lives and property at risk (Day, 1999) or in damage claims after the 1997 Red River flood which failed to meet flood risk standards (Morris-Oswald *et al.*, 1998). Since it has been the general policy of the federal government to provide financial disaster assistance when requested, this raises the question: if communities know that they are always going to receive assistance for a major flood what incentive is there to prevent such events?

In addition, Natural Hazards Center, University of Colorado and Disaster Research Institute, University of Manitoba (1999) have identified a weakness regarding eligible disaster-related costs associated with the DFAA. Eligible costs for recovery assistance are only available for returning structures to pre-disaster conditions and not for structural improvements or preventative projects that may reduce future flood risk. While this stipulation ensures that flood victims do not profit from this assistance by rebuilding a structure better than pre-flood conditions at taxpayer expense, it also deters mitigative measures. It was concluded that applying conditions for receiving financial assistance could foster greater mitigative measures. Since it is impossible to eliminate flood damages entirely, financial assistance will continue to be required as long as development in flood prone areas continues. Fostering recovery and long-term resilience, so individuals and communities can reduce the flood risk and be better prepared for future flood events, would assist in reducing future DFAA payments.

As well, DFAA claims made by First Nations residents can be confusing and problematic. DFAA guidelines recognize Indian and Northern Affairs Canada (INAC) as the federal agency responsible for financial assistance claims from Indian Reserves, but since First Nations people are generally treated as provincial residents their disaster claims should in fact be included with provincial claims to the federal government (Epp *et al.*, 1998). This has raised some confusion as to the roles of the various agencies involved in administering disaster assistance to First Nations.

Table III Accomplishments and Shortfalls of Ontario Conservation Authorities

Accomplishments	Issues or Shortfalls
• Maintain and operate real time Hydrologic Monitoring Network (in cooperation with the province and federal government). • Carry out flood forecasting and warning. • Operate and maintain flood control reservoirs and construct and maintain flood protection works (channels, dykes). • Work with municipalities to control development near major riverbanks and where necessary aid in stabilizing major river bank slopes. • Regulation of construction and filling within flood plains and wetlands. • Planning, reviewing and advising municipalities under the Planning Act to minimize flood impacts. • Define flood hazard by flood risk mapping. • Carry out a program of information and education on flood management. • Carry out a program of reforestation to aid in reducing flood flows and soil erosion. • Maintain preparedness to act during periods of floods, and maintain local knowledge of watershed and flooding issues.	• Some Authorities do not carry out adequate monitoring of flood plain development and adequate enforcement of the regulations. • Prosecution of violations not always supported by the courts. • Because weakness exists in the present Conservation Authorities Act, regulations have not controlled all flood plain development or addressed all policy objectives. The new revised Act will address many of these weaknesses. New generic regulations to implement the revised Act will be ready by the end of 2001. • Differences exist among Conservation Authorities' ability and expertise to carry out flood plain management. • Not all areas have a Conservation Authority to implement a flood management program. • Reductions in provincial funding have reduced the Authorities' ability to maintain flood infrastructure and the flood plain mapping program.

(Smith et al., 2000)

3.3 Disaster Assistance

While provinces and their municipalities take primary responsibility for dealing with natural disasters such as floods, it has been the general practice of the federal government to financially assist the provinces when requested (Fisheries and Environment Canada, 1976). Since 1970, Emergency Preparedness Canada has been providing federal disaster assistance through Disaster Financial Assistance Arrangements (DFAA). Compensation given to provinces for disasters is based on a per-capita cost-sharing formula (Table IV). There are also DFAA Guidelines that outline the eligible disaster-related costs covered by the federal government. Specific examples of provincial/territorial expenditures that are eligible and those that are not eligible for federal cost-sharing are provided by Emergency Preparedness Canada (1999), but generally include such activities as restoring public works to their pre-disaster condition and replacing and repairing basic, essential personal property of individuals, small businesses and farmsteads. The DFAA

were an improvement over previous federal assistance that was negotiated on an ad hoc, disaster-by-disaster basis (Fisheries and Environment Canada, 1976).

Table IV Cost-sharing formula outlining federal disaster financial assistance

Provincial Expenditure Eligible for Cost-Sharing	Provincial / Territorial Share (%)	Federal Share (%)
First $1 per capita	100	0
Next $2 per capita	50	50
Next $2 per capita	25	75
Remainder	10	90

(Adapted from Emergency Preparedness Canada, 1999)

The DFAA operates on a sliding scale based on population and damages. The increasing relationship between damages and assistance results in higher flood damages receiving greater federal assistance. As well, despite the policy that disaster assistance is to be withheld for any development built after designation (which excludes floodproofed development in the flood fringe) some evidence indicating the contradictory exists. For example, federal disaster assistance has not been withheld in high flood risk areas of the lower Fraser River, British Columbia, where development has increased the number of lives and property at risk (Day, 1999) or in damage claims after the 1997 Red River flood which failed to meet flood risk standards (Morris-Oswald *et al.*, 1998). Since it has been the general policy of the federal government to provide financial disaster assistance when requested, this raises the question: if communities know that they are always going to receive assistance for a major flood what incentive is there to prevent such events?

In addition, Natural Hazards Center, University of Colorado and Disaster Research Institute, University of Manitoba (1999) have identified a weakness regarding eligible disaster-related costs associated with the DFAA. Eligible costs for recovery assistance are only available for returning structures to pre-disaster conditions and not for structural improvements or preventative projects that may reduce future flood risk. While this stipulation ensures that flood victims do not profit from this assistance by rebuilding a structure better than pre-flood conditions at taxpayer expense, it also deters mitigative measures. It was concluded that applying conditions for receiving financial assistance could foster greater mitigative measures. Since it is impossible to eliminate flood damages entirely, financial assistance will continue to be required as long as development in flood prone areas continues. Fostering recovery and long-term resilience, so individuals and communities can reduce the flood risk and be better prepared for future flood events, would assist in reducing future DFAA payments.

As well, DFAA claims made by First Nations residents can be confusing and problematic. DFAA guidelines recognize Indian and Northern Affairs Canada (INAC) as the federal agency responsible for financial assistance claims from Indian Reserves, but since First Nations people are generally treated as provincial residents their disaster claims should in fact be included with provincial claims to the federal government (Epp *et al.*, 1998). This has raised some confusion as to the roles of the various agencies involved in administering disaster assistance to First Nations.

After the Manitoba flood of 1995 for example, INAC either deferred the process or referred the disaster claims of the Sioux Valley First Nations community to the provincial agencies giving the Sioux Valley the impression that they were being "brushed off" (Haque and Epp, 1998). Applying for assistance for repairing homes can also be problematic since the First Nations communities actually own the buildings and not necessarily the individuals or families who occupy the residences and the assistance program is designed to help the owner of the property (Rahman, 1998).

Disaster assistance for flooding of farmland and subsequent loss of production is available through other various programs. These programs are cost-shared by the federal and provincial governments and offer producers with risk management and income stabilization (Table V).

Table V Canada's Farm Income Safety Nets: Flood Protection

Program	Description and Comments
Crop Insurance *New Crop Insurance Agreements between the federal government and the provinces have been signed (since 1997)*	• Assure long-term assistance in stabilizing farmers' incomes by minimizing the economic effects of crop losses caused by natural hazards. • Protection levels of up to 90% of a crop's value may be purchased. • An unseeded acreage benefit, which compensates producers for land that could not be seeded due to natural conditions such as flooding, is also available through the program in many provinces (as part of basic crop insurance or purchased additionally). • Reseeding benefits are available in some provinces to aid in reseeding a field after initial crops are destroyed if early enough in the growing season to make reseeding a viable option. • Close to 100,000 farmers participated in the program insuring 50 million acres valued at $5 billion in 2000. • Indemnity payouts for the 2000 crop year are estimated to total more than $530 million, the highest payout level since the 1992 crop year. Premiums amounted to approximately $525 million, of which producers paid $171 million and the federal government contributed $185 million.
The Canadian Farm Income Program (CFIP) *A new ongoing disaster assistance program implemented for 2000-2002 under the recently signed Framework Agreement on Agricultural Risk Management.*	• The goal is to provide income stabilization (at a level of 70% of an historic average) for those facing short-term financial losses due to uncontrollable circumstances, such as flooding, resulting in extreme crop and income losses. • Unlike crop insurance, CFIP is a whole-farm program and not commodity-specific.

Table V Canada's Farm Income Safety Nets: Flood Protection

Program	Description and Comments
Crop Insurance *New Crop Insurance Agreements between the federal government and the provinces have been signed (since 1997)*	• Assure long-term assistance in stabilizing farmers' incomes by minimizing the economic effects of crop losses caused by natural hazards. • Protection levels of up to 90% of a crop's value may be purchased. • An unseeded acreage benefit, which compensates producers for land that could not be seeded due to natural conditions such as flooding, is also available through the program in many provinces (as part of basic crop insurance or purchased additionally). • Reseeding benefits are available in some provinces to aid in reseeding a field after initial crops are destroyed if early enough in the growing season to make reseeding a viable option. • Close to 100,000 farmers participated in the program insuring 50 million acres valued at $5 billion in 2000. • Indemnity payouts for the 2000 crop year are estimated to total more than $530 million, the highest payout level since the 1992 crop year. Premiums amounted to approximately $525 million, of which producers paid $171 million and the federal government contributed $185 million.
The Canadian Farm Income Program (CFIP) *A new ongoing disaster assistance program implemented for 2000-2002 under the recently signed Framework Agreement on Agricultural Risk Management.*	• The goal is to provide income stabilization (at a level of 70% of an historic average) for those facing short-term financial losses due to uncontrollable circumstances, such as flooding, resulting in extreme crop and income losses. • Unlike crop insurance, CFIP is a whole-farm program and not commodity-specific.

Program	Description and Comments
Net Income Stabilization Account (NISA) *In 1999, the federal government introduced changes allowing participants easier access to their NISA accounts.*	• The program allows producers to deposit a portion of their eligible net sales into their NISA account and receive matching government contributions. • This money is then available for withdrawal in years when income stabilization is needed. • Approximately 140,000 active participants in NISA with account balances valued at more than $3 billion. • NISA enhancement programs are also available in some provinces. These improve the income stabilizing power of NISA by allowing things such as higher NISA deposit limits or increased government contributions. Such programs are funded by money allocated to each province for province-specific companion programs.

(Wile and Ellis, 2001)

3.4 Water Policies, Acts and Programs

The succession of policies and practices dealing with water resources shows the evolution of thinking towards flood hazards. The three Water Acts preceding the Flood Damage Reduction Program are presented in Table VI, which summarizes their achievements and comment on their issues or shortfalls.

Table VI Acts that dealt with water resources in Canada

Year	Water Acts	Achievements and Comments
1867	Constitution Act, *formerly the British North American Act (BNA)*	• Provinces given proprietary rights over lands, mines, minerals and royalties, and by concept of riparian rights[1] have rights over water within their boundaries. • Federal government given legislative power, the power to pass laws in the areas of fisheries, navigation, peace, order, and good government of the country, and interprovincial and international matters. • *COMMENTS*: water resources issues often crossed jurisdictional boundaries resulting in conflicting water uses and made it difficult to specifically define federal or provincial responsibilities.
1953	Canada Water Conservation Assistance (CWCA) Act	• The first federal legislation directly concerned with water resource management; it provided federal financial assistance to provincial water storage projects. • *COMMENTS*: few small flood control works were qualified; rigid cost-sharing requirement[2] prevented major works, which had to be approved under special agreements outside the Act; limited scope for the projects with heavy influence on engineering structures; federal agencies simply responded to provincial requests and not involved in planning process; and lack of public participation.
1970	Canada Water Act (CWA)	• The CWA provided the means for a more active federal role in Canada's water resources management. • It offered new ways of dealing with water issues such as, comprehensive planning, seeking opinions of affected people, non-structural alternatives, and large scale planning. • *COMMENTS*: substantial improvement over traditional structural works, but engineering solutions continued to dominate and annual losses continued with new developments in flood-prone areas.

(Adapted from La Forest, 1969; Pearse and Quinn, 1996; Booth and Quinn, 1995; Environment Canada, 1983; Fisheries and Environment Canada, 1976)

[1] Special rights to water attached to land ownership.

[2] The Act provided federal financial assistance to provinces of up to 37.5 percent for conservation and control of water through structural controls, with the stipulation that federal contribution could not exceed that of the provincial (Environment Canada, 1983).

Program	Description and Comments
Net Income Stabilization Account (NISA) *In 1999, the federal government introduced changes allowing participants easier access to their NISA accounts.*	• The program allows producers to deposit a portion of their eligible net sales into their NISA account and receive matching government contributions. • This money is then available for withdrawal in years when income stabilization is needed. • Approximately 140,000 active participants in NISA with account balances valued at more than $3 billion. • NISA enhancement programs are also available in some provinces. These improve the income stabilizing power of NISA by allowing things such as higher NISA deposit limits or increased government contributions. Such programs are funded by money allocated to each province for province-specific companion programs.

(Wile and Ellis, 2001)

3.4 Water Policies, Acts and Programs

The succession of policies and practices dealing with water resources shows the evolution of thinking towards flood hazards. The three Water Acts preceding the Flood Damage Reduction Program are presented in Table VI, which summarizes their achievements and comment on their issues or shortfalls.

Table VI Acts that dealt with water resources in Canada

Year	Water Acts	Achievements and Comments
1867	Constitution Act, *formerly the British North American Act (BNA)*	• Provinces given proprietary rights over lands, mines, minerals and royalties, and by concept of riparian rights[1] have rights over water within their boundaries. • Federal government given legislative power, the power to pass laws in the areas of fisheries, navigation, peace, order, and good government of the country, and interprovincial and international matters. • *COMMENTS*: water resources issues often crossed jurisdictional boundaries resulting in conflicting water uses and made it difficult to specifically define federal or provincial responsibilities.
1953	Canada Water Conservation Assistance (CWCA) Act	• The first federal legislation directly concerned with water resource management; it provided federal financial assistance to provincial water storage projects. • *COMMENTS*: few small flood control works were qualified; rigid cost-sharing requirement[2] prevented major works, which had to be approved under special agreements outside the Act; limited scope for the projects with heavy influence on engineering structures; federal agencies simply responded to provincial requests and not involved in planning process; and lack of public participation.
1970	Canada Water Act (CWA)	• The CWA provided the means for a more active federal role in Canada's water resources management. • It offered new ways of dealing with water issues such as, comprehensive planning, seeking opinions of affected people, non-structural alternatives, and large scale planning. • *COMMENTS*: substantial improvement over traditional structural works, but engineering solutions continued to dominate and annual losses continued with new developments in flood-prone areas.

(Adapted from La Forest, 1969; Pearse and Quinn, 1996; Booth and Quinn, 1995; Environment Canada, 1983; Fisheries and Environment Canada, 1976)

[1] Special rights to water attached to land ownership.

[2] The Act provided federal financial assistance to provinces of up to 37.5 percent for conservation and control of water through structural controls, with the stipulation that federal contribution could not exceed that of the provincial (Environment Canada, 1983).

In the early 1970s, the federal and provincial governments realized the shortfalls of the current reactive strategy of structural flood control measures and disaster assistance (Watt, 1995). The Flood Damage Reduction Program (FDRP) was a new way of thinking for managing flood hazards, which emerged in 1975. This new program was a national commitment that structural solutions would, in principle, not be the first and only approach to deal with flooding (de Loë, Forthcoming). It involved flood risk mapping, designation and zoning, flood warning and forecasting, land-use acquisition (there was little of this in practice), and floodproofing combined with structural solutions (Fisheries and Environment Canada, 1976). This was a cooperative program arranged under General Agreements, on a province-by-province basis, and supplemented by subsidiary agreements on mapping and possible sub-agreements of flood-forecasting, structural controls, and other studies. The maps were intended to serve as a basis for land use planning decisions and building codes. The General Agreements encouraged local authorities to zone according to the flood risk outlined by these maps. Agreements had lifespans of up to 10 years and were not to be renewed at the end of their operating periods and after the 1990s the funding for agreements with provinces declined significantly (Watt, 1995; Booth and Quinn, 1995); currently, only the agreements with Québec and British Columbia remain in force (Table VII) . In the early 1990s, the intention was that the program would enter a phase of maintenance and continuance but this has been abandoned (Watt, 1995; de Loë, Forthcoming).

Table VII Expiry Dates of the Flood-Risk Mapping and Policy Agreements [1]

Province or Territory	Expiry Date for "Agreements for Policies"	Expiry Date for "Agreements for Mapping"
Alberta	March 31, 1999	March 31, 1997
British Columbia	March 31, 2003	March 31, 1998
Aboriginal Lands [2]	---	March 31, 1995
Manitoba	March 31, 1999	March 31, 1996
New Brunswick	March 31, 2000	August 31, 1998
Newfoundland	March 31, 2001	March 31, 1996
Northwest Territories	March 31, 1993	March 31, 2000
Nova Scotia	June 22, 2000	June 22, 1995
Ontario	March 31, 1997	March 31, 1992
Québec	March 31, 2002	March 31, 1997
Saskatchewan	March 31, 2000	March 31, 1995

Source: Environment Canada (1996); Environment Canada (1999)

[1] *Updated to March 31, 1999; Prince Edward Island and Yukon did not join the program.*
[2] *The Memorandum of Understanding between Environment Canada and Indian and Northern Affairs Canada for the mapping of flood risks on Aboriginal lands expired on March 31, 1995; approximately 40 reserves or communities were mapped with the full cooperation of Band Councils (designation was not part of this arrangement).*

In the early 1970s, the federal and provincial governments realized the shortfalls of the current reactive strategy of structural flood control measures and disaster assistance (Watt, 1995). The Flood Damage Reduction Program (FDRP) was a new way of thinking for managing flood hazards, which emerged in 1975. This new program was a national commitment that structural solutions would, in principle, not be the first and only approach to deal with flooding (de Loë, Forthcoming). It involved flood risk mapping, designation and zoning, flood warning and forecasting, land-use acquisition (there was little of this in practice), and floodproofing combined with structural solutions (Fisheries and Environment Canada, 1976). This was a cooperative program arranged under General Agreements, on a province-by-province basis, and supplemented by subsidiary agreements on mapping and possible sub-agreements of flood-forecasting, structural controls, and other studies. The maps were intended to serve as a basis for land use planning decisions and building codes. The General Agreements encouraged local authorities to zone according to the flood risk outlined by these maps. Agreements had lifespans of up to 10 years and were not to be renewed at the end of their operating periods and after the 1990s the funding for agreements with provinces declined significantly (Watt, 1995; Booth and Quinn, 1995); currently, only the agreements with Québec and British Columbia remain in force (Table VII) . In the early 1990s, the intention was that the program would enter a phase of maintenance and continuance but this has been abandoned (Watt, 1995; de Loë, Forthcoming).

Table VII Expiry Dates of the Flood-Risk Mapping and Policy Agreements [1]

Province or Territory	Expiry Date for "Agreements for Policies"	Expiry Date for "Agreements for Mapping"
Alberta	March 31, 1999	March 31, 1997
British Columbia	March 31, 2003	March 31, 1998
Aboriginal Lands [2]	—	March 31, 1995
Manitoba	March 31, 1999	March 31, 1996
New Brunswick	March 31, 2000	August 31, 1998
Newfoundland	March 31, 2001	March 31, 1996
Northwest Territories	March 31, 1993	March 31, 2000
Nova Scotia	June 22, 2000	June 22, 1995
Ontario	March 31, 1997	March 31, 1992
Québec	March 31, 2002	March 31, 1997
Saskatchewan	March 31, 2000	March 31, 1995

Source: Environment Canada (1996); Environment Canada (1999)

[1] Updated to March 31, 1999; Prince Edward Island and Yukon did not join the program.
[2] The Memorandum of Understanding between Environment Canada and Indian and Northern Affairs Canada for the mapping of flood risks on Aboriginal lands expired on March 31, 1995; approximately 40 reserves or communities were mapped with the full cooperation of Band Councils (designation was not part of this arrangement).

3.5 Post-Audits of the Flood Damage Reduction Program

There have been various assessments of different aspects of the FDRP made to date, which are highlighted here. The discussion is divided into issues of designation and regulation, comparative analyses, future flood damage reduction studies, and comments on future damage payouts.

3.5.1 Issues of Designation and Regulation

An important aspect of the FDRP involved the designation of floodplains and the subsequent regulation of development in these flood risk areas by municipalities or other bodies such as conservation authorities. The following studies present issues regarding designation and regulation such as weaknesses and effectiveness of regulation, and property values after designation.

Forget *et al.* (1999) assessed the effectiveness of designation and diking of floodplains under the FDRP for four municipalities in Québec. They concluded that these municipalities permitted an increase in occupancy and economic value in their floodplains, exposing a greater proportion of the population to potential flood damages. Flood damage reduction measures based on designation and mapping of floodplains had no impact on occupancy and failed to reduce or even halt flood damages for the areas that were studied. The study suggested that a long list of automatically exempted undertakings in the Canada-Québec Agreement and withdrawal clauses in the Agreement allowed municipalities to pursue existing development. The study also found that diking in these four regions of Québec did not have an effect on the occupancy or property values in the floodplains, probably due to the fact that dikes were constructed only in areas that were already built-up. However, Forget *et al.* (1999) did raise the issue that the dikes offered a possible false sense of security and also noted on their highly variable state and maintenance. Development or floodproofing behind structures should therefore take into consideration that dikes may eventually fail and may cause increased potential damages to property. The following case in Regina, Saskatchewan, is an excellent example of development behind dikes that requires floodproofing to ensure protection of property:

> "Regina is one of few cities that call for floodproofing by elevating new developments behind dikes. New developments must be constructed so that the grade elevation must be at least at the 1:500 flood level and the first floor elevation at the 1:500 plus 0.6 m level, irrespective of the presence or absence of a dike. The province must approve all new subdivision plans and the only flexibility in the zoning requirement is the possibility of waiving the 0.6 m freeboard. The province of Saskatchewan uses a 1:500 regulatory floodplain, which is not substantially higher than the 1:100 floodplain (there are some exceptions, notably Prince Albert)" (Halliday, 2001).

A second Québec study by Roy *et al.* (1997) looked at the evolution of the Canada-Québec agreements on flood damage reduction and the extent that the program has been implemented in the Chaudière River basin. They concluded that despite a ban on building in the 0-20 year zone, many buildings (especially residential ones) were erected in this strong current zone. This construction was legal since it was connected to an existing aqueduct and/or sewage network in

place before the adoption of the Regional County municipalities' regulation resulting from the Canada-Québec Agreement. The study also notes other aspects for the continued development in flood prone areas such as the fact that: buildings located on floodplains are restored repeatedly and even fully rebuilt after floods; building relocation is not encouraged since there is no financial assistance for this; and downtown areas are granted tax freezes for building restoration and exemptions for construction since they areas of high economic activity. These findings are confirmed by CSTGB (1997), which stated that only 50 out of 232 Québec municipalities considered risk zones in setting urban boundaries, that some municipalities did not even consider it their task to enforce articles under the Canada-Québec Agreement, and that the Agreement had provisions allowing for exemptions in issuing construction permits under some circumstances.

Studies by Shrubsole *et al.* (1995) and Shrubsole *et al.* (1997) respectively confirmed that regulations were administered in an equitable and efficient manner in London and Glen Williams, Ontario by their conservation authorities and also appear to be effective. However, both raise the same issues regarding implementation, which specifically include problems controlling all development activity and addressing policy objectives due to weaknesses in the Conservation Authorities Act, a lack of judicial and participating municipal support in prosecuting violations, and inadequate monitoring and enforcement of developmental activity. de Loë (Forthcoming) has noted that these studies are effectively evaluations of provincial, municipal and conservation authority policy and practice and not necessarily the FDRP since in Ontario floodplain regulation began well before the establishment of this national program. However, it does reveal the success of conservation authorities in floodplain regulation as compared to areas where no local level organization exists.

Another concern of floodplain designation under the FDRP has been the impact on property value. One point of view regarding floodplain regulation and designation is that the formal identification of flood hazard would reduce its marketability and therefore property value (Schaefer, 1990), which would be a negative outcome of implementing this management strategy to limit development. A review by Schaefer (1989) found that out of seven different study areas from four provinces only one had property values significantly lowered (15 to 20%) as a result of regulations compared to the other areas where property values have increased or remained the same. Shrubsole *et al.* (1995) also found that there was no impact on property value after designation in London, Ontario. Floodplain regulations therefore do not necessarily negatively impact adjacent land values, which provide positive support for implementing floodplain regulations and designation.

3.5.2 Comparative Analyses

This section outlines analyses of the FDRP through comparative studies such as benefits versus costs, comparing different floodplain management strategies for the same storm event, and superimposing precipitation amounts from a past flood event to different watersheds.

A benefit-cost analysis of four FDRP projects for Ontario (Hanlon's Creek, Moira River, Atikokan River, and Etobicoke Creek) was conducted by Millerd *et al.* (1994) to illustrate the application of this program in Ontario. For Hanlon's Creek and Moira River there was no doubt that the benefits of the FDRP in avoiding potential flood damages were found to exceed costs of

implementing and managing the project. Since the Atikokan River project was an area of little economic activity it was concluded that benefits from the program would be achieved when and if there was economic growth. As for the Etobicoke Creek project, the FDRP was simply a continuation and improvement of the previous management practices to limit floodplain development in Ontario. In addition, all four projects were found to have considerable administrative and environmental benefits.

Economic benefits of flood hazard mapping and accompanying land use regulation have also been witnessed in the floodplain of Pilot Butte Creek in Regina, Saskatchewan (Weiss, 1987). Benefit and cost analysis of floodplain mapping was conducted. A developer's original plans were compared to amended plans for a new subdivision that included floodplain management and flood proofing requirements. This in addition to data from a July 1983 rainstorm allowed for the economic analysis of benefits and costs of floodplain mapping. The analysis demonstrated that the reduction in mean annual damages due to the changes in subdivision design was greater than the average annual cost of the mapping and required flood proofing.

Brown *et al.* (1997) compared management approaches taken in two different areas for the same flood event to assess the FDRP. This study looked at the extensive flooding that occurred in Michigan ($500 million US) versus the relatively minimal flooding in Ontario (under $500,000) during the same extreme rainfall events in the months of August and September 1986. After comparing the physiography, land-use, floodplain development and policies, rainfall and runoff they concluded that climatological and watershed responses of Michigan and Ontario were similar, but flood damages were substantially different. The substantially less damage that resulted in Ontario was attributed to the fact that Ontario has had an "ambitious and comprehensive" flood-reduction program since the mid-1950s compared to the limited floodplain restrictions in much of the affected Michigan area. Benefits of the long-standing, non-structural management practices are clearly presented in this comparative study.

Another comparison involved superimposing the Saguenay 1996 flood event over the Grand River Watershed to quantify what would happen to this watershed in southern Ontario given the same precipitation conditions as the Saguenay 1996 floods (Boyd, 1997; Boyd, 1996). After a comparison of the flood mitigation activities in both areas, it was concluded that if the precipitation event that caused the Saguenay flood occurred in the Grand River Watershed, damages would be a lot less. This was attributed to the structural and non-structural activities put into place by the Grand River Conservation Authority (GRCA), which is responsible for implementing measures to reduce flooding and is the single agency responsible for operating flood control reservoirs (seven major reservoirs), providing flood warning, and regulating floodplain development. Results of the modeling generally revealed that the Saguenay flood would be within the current Regulatory Storm design flows throughout the basin (except for the very lower portion of the Grand River). In addition, it was estimated that without floodplain regulations imposed by the GRCA, unprotected areas would suffer $5 million in flood damages if a similar storm as that which occurred during the Saguenay floods fell on the Grand River basin. Also, damages were concluded to be a lot less in the Grand River basin compared to the Saguenay region due to the extensive flood monitoring, warning and reduction systems implemented by the GRCA.

3.5.3 Future Flood Damage Reduction Studies

Other important issues are also pointed out in assessments of FDRP evaluations or proposed evaluations. A study by de Loë and Shrubsole (1998), assessing a proposed floodplain management evaluation methodology, noted the problem of determining the extent to which the FDRP actually contributed to the successful recognition, delineation, and management of floodplains. Initiatives in floodplain management, such as the ones taken by British Columbia, Alberta, and Ontario were pursued preceding or parallel to the FDRP initiatives (see Doughty-Davis, 1976; Watt, 1995; and Giles, 1976, respectively), which make it difficult to specifically assess the benefits of this national program versus provincial initiatives. As well, de Loë and Mitchel (1995) point out the difficulty in considering the full range of costs and benefits in economic analyses. They argued for a limited evaluation methodology for the FDRP, focusing on difficult-to-quantify benefits (e.g., improvements in land use and zoning, increased governmental co-operation, ecologically-sensitive area protection) and making pertinent people more aware of them. This methodology was subsequently implemented by de Loë and Wojtanowski (Forthcoming). This study identified that improved environmental features could be credited to the FDRP and important in comparison to the additional costs, such as increased expenses for developers. In that light, the study concluded that the federal government's decision to terminate the FDRP, based on the argument that it was a narrow, single-sector initiative, was lamentable.

3.5.4 Future DFAA Costs

The federal and provincial governments expended approximately $530 million in DFAA support on disaster response and recovery during 1980 to 1994 inclusive, and about half ($262 million) of this was for floods. Half of the DFAA support for floods ($131 million) was the federal government's contribution, resulting in an average federal flooding assistance share of about $25 million per year. In the 1995 to 1999 period, federal and provincial DFAA eligible expenditures amounted to $1,395 million, of which $590 million was in response to flooding. Recent natural disasters, such as the Québec and Manitoba floods, and the Eastern Canada Ice Storm, accounts for this extraordinary increase in DFAA costs. Of the $590 million for floods, $484 million (82%) was the federal share. Hopefully this is not to be considered normal, as it amounts to almost $97 million per year.

A conservative assumption is that $30 million per year is a "to-be-expected" annual federal DFAA cost share in response to eligible flooding disasters. If only 10% of that amount could be avoided by, for example, the continuation of a flood risk area mapping and designation program, accompanied by adequate provincial and municipal enforcement actions and further supported by appropriate insurance and loan-caveat financial disincentives, then the saving to the federal and provincial governments would be significant. Such an approach would likely more than pay for itself, especially in the long-term.

4.0 Summary of Panel Deliberations

The Independent Expert Panel met December 15th to 16th, 1999, in Hull, Québec, to discuss issues of flood hazard management and put forward recommendations needed to mitigate future losses. There was agreement that flood management in Canada is currently at a significant crossroad. After reviewing a draft outline of the report, which had been prepared in advance, the Panel decided on the structure and main directions that the report should take. The ideas and messages during the Working Group discussions were incorporated into this section. The following synthesis presents the main findings organized under three main headings of, 'Reducing Flood Damage and Potential', 'Research', and 'Institutional and Policy Environments', from which 15 recommendations were made by the Panel.

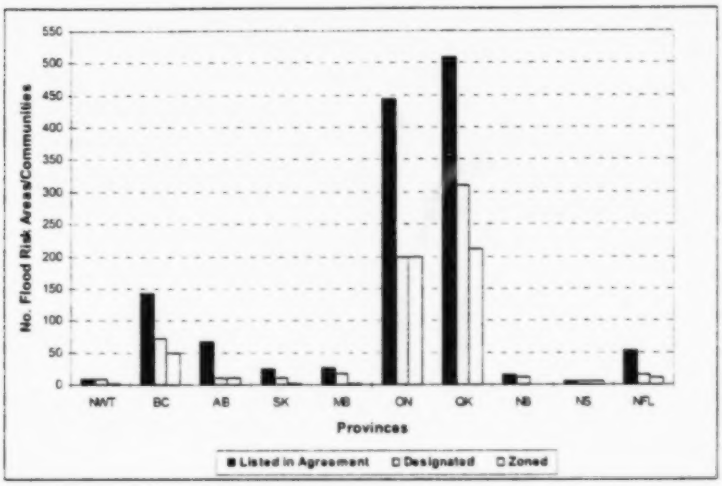
4.1 Reducing Flood Damage and Potential

The Panel considers that immediate steps to avoid further increases in flood damage potential and to reduce existing vulnerabilities to flood hazard are now warranted. The suggested actions to be taken are presented below under the categories of mapping, new technology, flood forecasting and warning, monitoring and enforcement, economic instruments, co-operative alliances, information and education, and resilient communities.

4.1.1 Floodplain Mapping

Flood risk maps are essential for the successful implementation of a range of flood hazard mitigation measures (such as land use regulation, insurance, emergency measures, and assessing damage potential) and important in controlling future development in these hazardous areas (Handmer, 1980; Fisheries and Environment Canada, 1976). They may also help in informing the public and influencing perceptions of risk, since the more information provided the more likely people will expect the event to return (Tversky and Kahnemann, 1982). This can supplement information via the media, which may be more significant in raising flood awareness and motivating mitigation activity (Handmer, 1980). In light of the importance of floodplain mapping it is important that it is continued, especially for flood risk areas where maps do not yet exist. In order for floodplain mapping and updating to continue it may be necessary for a cost-sharing program to replace the FDRP, especially for provinces that may not be able to cover all the expenses of generating or updating these flood risk maps on their own. Figure 4.1 indicates the areas or communities listed in the General Agreements of the FDRP to be mapped, as well as the numbers of these that were in fact mapped and designated as floodplain. It also indicates those areas or communities that had zoning put into place (this figure is only current as of July 1995). As well, floodplain mapping needs to be kept up to date and accurate due to land use changes, changes in channel morphology, and climate trends and projected changes, which change flood frequencies and magnitudes. These maps should be updated for these factors, and if possible, specifically after each major flood event. These need to be addressed in mapping and delineating the floodplain and even in modeling flood scenarios if modeling is used in producing the floodplain map. Floodplain maps also need to be kept up to date to avoid potential liability issues of those that are responsible for maintaining public safety.

Figure 4.1 The number of flood risk areas or communities which were listed in the Agreements of each province, mapped and designated (or interim designated) as floodplain, and the designated areas which had zoning put into place by municipal / regional / provincial governments (data up until June 30th, 1995) *(Adapted from Watt, 1995).*



Recommendation 1: Flood risk maps must be kept accurate and up to date.

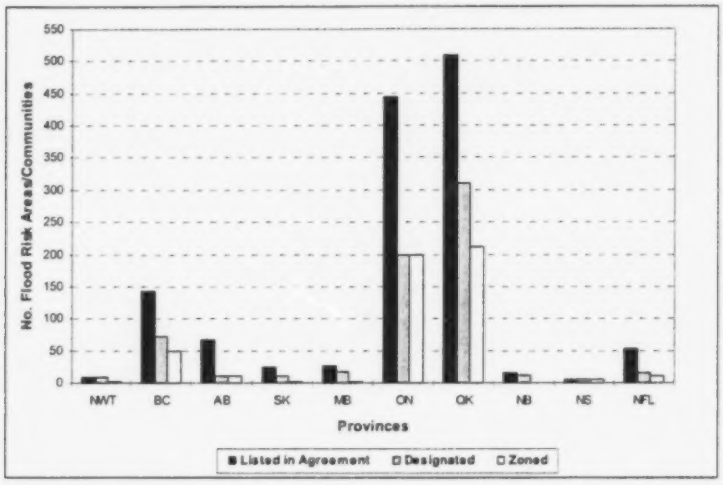
4.1.2 Geographic Information System and New Technology

A geographic information system (GIS) consists of a set of integrated digital maps and associated spatial and attribute information that are electronically linked. GIS is capable of capturing, storing, managing, and displaying spatially referenced data, however, its hallmark is its ability to perform objective, rigorous spatial analysis. In the context of floods, the utility and range of applications in the areas of emergency management and the evaluation of loss and damage have been rapidly evolving in the last two decades. The application of this tool to enhance risk and damage assessment, operational flood warning and emergency response, and floodplain management are well underway in some areas of Canada:

- An emerging area of GIS application in flood mitigation includes flood risk assessment through real-time monitoring and programs in integrated watershed and natural resource management. During the 1997 Red River Valley floods, Manitoba Water Resources used RADARSAT[1] (RSI, Richmond, British Columbia) and other real-time imagery to monitor,

[1] See http://www.space.gc.ca/csa_sectors/earth_environment/radarsat/default.asp for more information.

Figure 4.1 The number of flood risk areas or communities which were listed in the Agreements of each province, mapped and designated (or interim designated) as floodplain, and the designated areas which had zoning put into place by municipal / regional / provincial governments (data up until June 30th, 1995) *(Adapted from Watt, 1995).*



Recommendation 1: Flood risk maps must be kept accurate and up to date.

4.1.2 Geographic Information System and New Technology

A geographic information system (GIS) consists of a set of integrated digital maps and associated spatial and attribute information that are electronically linked. GIS is capable of capturing, storing, managing, and displaying spatially referenced data, however, its hallmark is its ability to perform objective, rigorous spatial analysis. In the context of floods, the utility and range of applications in the areas of emergency management and the evaluation of loss and damage have been rapidly evolving in the last two decades. The application of this tool to enhance risk and damage assessment, operational flood warning and emergency response, and floodplain management are well underway in some areas of Canada:

- An emerging area of GIS application in flood mitigation includes flood risk assessment through real-time monitoring and programs in integrated watershed and natural resource management. During the 1997 Red River Valley floods, Manitoba Water Resources used RADARSAT[1] (RSI, Richmond, British Columbia) and other real-time imagery to monitor,

[1] See http://www.space.gc.ca/csa_sectors/earth_environment/radarsat/default.asp for more information.

forecast, and predict flood levels, crest migration, and flood impact. RADARSAT International was able to successfully map the flood extent utilizing ERS-1 imagery, which also employs a radar sensor with the capability to penetrate cloud cover. This information was provided to Manitoba Emergency Measures Organization (MEMO) within 24 hours of image acquisition and effectively used to monitor the flood's impact.

- In southern Ontario, the Grand River Conservation Authority (GRCA) has initiated a project to develop flood extent mapping in key river reaches using GIS technology. This will update the mapping of regulatory floodlines developed over the past 25 years, which have become outdated and have not always provide useful information in terms of required information for emergency response.

- GIS has made the updating and maintenance of maps for the area of Waterford River in Mount Pearl, St. John's, Newfoundland possible in a cost effective manner.

In addition, there are useful examples from outside of Canada that have demonstrated the utility of this technological tool such as:

- The development of a natural resource inventory and interactive GIS database for use in flood related decision-making and future planning (Myers *et al.*, 1999).

- The implementation of pilot projects in North Carolina where the State government provided eleven local government offices with the GIS database required to conduct a comprehensive hazard vulnerability assessment that includes flooding; while training and demonstrations of on the use of the GIS systems were provided by private sector partners (NCDEM, 1998).

- The integration of GIS with hydrological/hydraulic modeling which has proven to be feasible, mutually beneficial to GIS users and hydrological modelers, a quick and easy way to update maps compared to existing methods, and able to be adapted to simulate the impacts of various planning scenarios such as land use changes or infrastructure (PETRIS, 1999).

These types of examples could be used as a benchmark for GIS applications in flood mitigation across Canada. However, modifications may be necessary to accommodate the varied geographical, regional, historical, social characteristics, and priorities of various regions of the country.

While GIS is a promising tool, the technology also brings with it various concerns which technicians and decision makers must be aware of:

- Data quality issues identified by Watt and Paine (1992) for paper maps exist for GIS-created maps and are magnified since spatial data may be incompatible due to issues of scale and varying quality.

- These tools will only be as effective as the raw data that is used. Issues regarding the coupling of GIS and hydraulic modeling may exist if there is inadequate hydraulic and water level data for calibrating and verifying the models, which may not produce the desired products.

- There may be initial investment costs in technology and/or training if provincial and local governments do not already have access and knowledge in this area.

- Digital data can be easily copied and distributed. Thus in light of issues of legal liability relating to floodplain designation, managers will need to ensure that the data are used appropriately.

It is therefore important not to dismiss the more traditional forms of producing flood risk maps. The most effective way of producing these maps, which may differ for each province or territory depending on the resources and technology they have access to, should be investigated and pursued.

Another example of a modeling tool, currently being developed at Emergency Preparedness Canada, is the Natural Hazards Electronic Map and Assessment Tools Information System (NHEMATIS). It allows the user to specify a location on the map and define the number of meters above that point that the flood will reach. NHEMATIS then calculates the extent of the flood directly from the included Digital Elevation Model (DEM). This approach generates flood extents rapidly and simply, but does not take into account hydraulic issues. It is best to consider the output of this approach as being a way of exploring the topography of an area rather than generating highly accurate flood forecasts. It should be noted that the accuracy of the DEM-based approach depends critically on the accuracy and precision of the DEM being used. If the vertical accuracy of the DEM is very poor then predictions will likewise be poor. In NHEMATIS, flood damage is handled with two simple rules for major and minor structural damage. Damage cost estimates are subsequently calculated on a cost per square meter basis.

Recommendation 2: New technological tools such as GIS and NHEMATIS can be effective tools and should be increasingly applied to assessing flood risk, the long-term management of the floodplain, and in updating flood risk maps.

4.1.3 Flood Forecasting and Warning

Timely and accurate flood forecasts are crucial for providing advance warning of approaching floods. This advance warning can significantly reduce flood damages and losses by providing an estimate of the area to be flooded to municipalities, appropriate organizations, and potentially affected individuals. Emergency plans such as evacuation, removing items, property and livestock, emergency diking and other flood protection measures, and dam and reservoir level operation can then be put into effect to reduce the potential flood damages and losses. Forecasting and warning was pivotal in preventing property damage and loss of life during the 1997 Red River flood (Morris-Oswald *et al.*, 1998). A key aspect of providing these flood

forecasts and the subsequent warnings is the hydrometric and meteorological monitoring capacity or data available. Despite the importance of collecting the data to base flood forecasts and models, there has been a reduction of water monitoring water gauges in certain provinces, while other provinces face the need for expanded real-time monitoring under financial pressures. A key concern in British Columbia, for example, is the recent incremental reduction in the hydrometric survey. Federal and provincial budgets seem to be regularly reduced with respect to water monitoring gauges. Fewer gauges affect the quantity and quality of water flow data, thereby reducing flood frequency analysis and forecasting ability. This jeopardizes the detection capability of future flood hazard due to changes such as climate or land use.

Recommendation 3: Flood forecasts and warnings should remain an important component of flood hazard mitigation. Real-time hydrological measurement networks should be adequately maintained or expanded to provide timely and accurate data for numerical flood forecast models and subsequent warnings.

4.1.4 Monitoring and Enforcement

Monitoring and enforcement are key aspects for reducing flood damage potential. The success of policies and programs in conjunction with flood risk mapping to limit floodplain development will be limited without strict adherence ensured by monitoring and enforcement of floodplain regulations, which has been problematic in some areas. In Ontario for example, the $1,000 maximum fine for not complying with floodplain regulations is inadequate and has not been assertively applied by the Ontario Courts, which have also been reluctant to remove buildings that have violated floodplain regulations (Shrubsole *et al.*, 1995; Shrubsole *et al.*, 1997). Enforcement problems were also noted in Manitoba, where only 63% of new homes in designated flood areas complied with a regulation that required the main floor of a home with a basement to be 1 meter above the 1979 flood level (International Joint Commission, 1997). Manitoba is now, however, conducting compliance checks for all remedial works from the 1997 flood carried out by experienced staff under the Canada-Manitoba Flood Proofing Program. As well, since local municipalities are in charge of zoning, land use, and development, provincial agencies can only express concerns about development located in flood-prone areas. In addition, there are no consequences for failure to comply and notice of non-compliance is often not given out until well after the structure is completed.

Recommendation 4: Strengthen monitoring and enforcement of policies and programs to help achieve greater adherence to floodplain regulations, which would help reduce or prevent flood damage potential in the long term.

4.1.5 Economic Instruments

Economic instruments such as user taxes or insurance and the user pay principal were discussed to reduce floodplain development and flood damages. These types of tools would also help

- These tools will only be as effective as the raw data that is used. Issues regarding the coupling of GIS and hydraulic modeling may exist if there is inadequate hydraulic and water level data for calibrating and verifying the models, which may not produce the desired products.

- There may be initial investment costs in technology and or training if provincial and local governments do not already have access and knowledge in this area.

- Digital data can be easily copied and distributed. Thus in light of issues of legal liability relating to floodplain designation, managers will need to ensure that the data are used appropriately.

It is therefore important not to dismiss the more traditional forms of producing flood risk maps. The most effective way of producing these maps, which may differ for each province or territory depending on the resources and technology they have access to, should be investigated and pursued.

Another example of a modeling tool, currently being developed at Emergency Preparedness Canada, is the Natural Hazards Electronic Map and Assessment Tools Information System (NHEMATIS). It allows the user to specify a location on the map and define the number of meters above that point that the flood will reach. NHEMATIS then calculates the extent of the flood directly from the included Digital Elevation Model (DEM). This approach generates flood extents rapidly and simply, but does not take into account hydraulic issues. It is best to consider the output of this approach as being a way of exploring the topography of an area rather than generating highly accurate flood forecasts. It should be noted that the accuracy of the DEM-based approach depends critically on the accuracy and precision of the DEM being used. If the vertical accuracy of the DEM is very poor then predictions will likewise be poor. In NHEMATIS, flood damage is handled with two simple rules for major and minor structural damage. Damage cost estimates are subsequently calculated on a cost per square meter basis.

Recommendation 2: New technological tools such as GIS and NHEMATIS can be effective tools and should be increasingly applied to assessing flood risk, the long-term management of the floodplain, and in updating flood risk maps.

4.1.3 Flood Forecasting and Warning

Timely and accurate flood forecasts are crucial for providing advance warning of approaching floods. This advance warning can significantly reduce flood damages and losses by providing an estimate of the area to be flooded to municipalities, appropriate organizations, and potentially affected individuals. Emergency plans such as evacuation, removing items, property and livestock, emergency diking and other flood protection measures, and dam and reservoir level operation can then be put into effect to reduce the potential flood damages and losses. Forecasting and warning was pivotal in preventing property damage and loss of life during the 1997 Red River flood (Morris-Oswald *et al.*, 1998). A key aspect of providing these flood

forecasts and the subsequent warnings is the hydrometric and meteorological monitoring capacity or data available. Despite the importance of collecting the data to base flood forecasts and models, there has been a reduction of water monitoring water gauges in certain provinces, while other provinces face the need for expanded real-time monitoring under financial pressures. A key concern in British Columbia, for example, is the recent incremental reduction in the hydrometric survey. Federal and provincial budgets seem to be regularly reduced with respect to water monitoring gauges. Fewer gauges affect the quantity and quality of water flow data, thereby reducing flood frequency analysis and forecasting ability. This jeopardizes the detection capability of future flood hazard due to changes such as climate or land use.

Recommendation 3: Flood forecasts and warnings should remain an important component of flood hazard mitigation. Real-time hydrological measurement networks should be adequately maintained or expanded to provide timely and accurate data for numerical flood forecast models and subsequent warnings.

4.1.4 Monitoring and Enforcement

Monitoring and enforcement are key aspects for reducing flood damage potential. The success of policies and programs in conjunction with flood risk mapping to limit floodplain development will be limited without strict adherence ensured by monitoring and enforcement of floodplain regulations, which has been problematic in some areas. In Ontario for example, the $1,000 maximum fine for not complying with floodplain regulations is inadequate and has not been assertively applied by the Ontario Courts, which have also been reluctant to remove buildings that have violated floodplain regulations (Shrubsole *et al.*, 1995; Shrubsole *et al.*, 1997). Enforcement problems were also noted in Manitoba, where only 63% of new homes in designated flood areas complied with a regulation that required the main floor of a home with a basement to be 1 meter above the 1979 flood level (International Joint Commission, 1997). Manitoba is now, however, conducting compliance checks for all remedial works from the 1997 flood carried out by experienced staff under the Canada-Manitoba Flood Proofing Program. As well, since local municipalities are in charge of zoning, land use, and development, provincial agencies can only express concerns about development located in flood-prone areas. In addition, there are no consequences for failure to comply and notice of non-compliance is often not given out until well after the structure is completed.

Recommendation 4: Strengthen monitoring and enforcement of policies and programs to help achieve greater adherence to floodplain regulations, which would help reduce or prevent flood damage potential in the long term.

4.1.5 Economic Instruments

Economic instruments such as user taxes or insurance and the user pay principal were discussed to reduce floodplain development and flood damages. These types of tools would also help

reduce the costs paid by the general public for floodplain management and flood damages that only directly affect individuals residing in flood prone areas.

A *user tax* is a tax levied on the user of a specific service so that the costs of the service are not borne by the general taxpayer. Such a tax could be implemented for those that occupy or develop in identified flood risk zones with the revenue generated directed to the costs of flood management, disaster assistance and, importantly, reducing future flood hazards. This would be an equitable way of distributing the costs of flood management to only those who directly benefit from occupying floodplains or developing there. In addition, this type of tax could be used as an incentive to limit floodplain development or to relocate outside high-risk areas. It could also act as a penalty or disincentive for those who continued to occupy flood risk areas or simply rebuilt their property after a flood event without taking appropriate floodproofing measures.

In Canada, flood insurance policies are available for commercial properties and operations, but generally not for residential properties. While flood insurance was discussed as a market driven approach to floodplain management there were some arguments against this tool. One reason for the argument against flood insurance is that the public is not usually willing to pay the high flood insurance premiums and it is not profitable for the insurance companies to cover flood damage at affordable premiums making the implementation of residential flood insurance difficult (Miller, 1997). The possibility of implementing an affordable flood insurance scheme could, however, promote well-managed floodplains. This would require further careful study before being implemented to ensure that an appropriate flood insurance model is possible in Canada. Natural Hazards Center, University of Colorado and Disaster Research Institute, University of Manitoba (1999) suggested two possible schemes for the implementation of insurance in flood risk areas: (i) the purchase of flood insurance to be mandated as part of municipal taxes, for those occupying floodplains; and (ii) mandatory insurance similar to car insurance where the cost is determined by the level of risk, the personal mitigation action taken, and the level of protection sought. Flood insurance would help provide an indication of the risk of floodplain occupancy since higher flood risk areas or ones without sufficient floodproofing would be subject to higher premiums.

Any program or policy should include the general principle that those who receive the benefits should also bear the necessary costs. This is also termed the *user pay* principle- those who use resources should pay for them. In the context of flood damage cost reduction, those who benefit from using flood prone land should pay the costs of flood protection and mitigation or be prepared to bear the costs of flood damages. Individuals would need to be well informed of the risks of inhabiting flood prone areas, but would be responsible for any damages to their property incurred as a result of a flood.

The implementation of a user tax, flood insurance and/or user pays instrument would better distribute the costs to those that were actually receiving the benefits of inhabiting floodplain regions and perhaps influence people to develop and inhabit less hazardous areas. However, the success of these instruments would be limited as long as individuals occupying or developing in floodplains knew that government financial assistance would be available after every flood event to rebuild or restore their damaged property. It would therefore be important for government to strictly adhere to their policy of not providing financial support for developing in flood risk areas

or developing without adequate floodproofing, which has not been the case in the past. The loss of eligibility to DFAA would also be another economic instrument that would encourage regulation of development in high flood risk areas. The economic instruments discussed here would be a drastic change from the current practice in Canada where the costs for flood disasters or prevention are generally spread among society including those not gaining any benefit from flood prone lands. It is also important to note that any implemented economic program must be affordable to both government and the general person. These programs should also not create severe hardship to those that already residing in flood risk areas or vulnerable or disadvantaged people. For this reason it would be necessary to study the feasibility of implementing these economic strategies and the ability of government to strictly stand by their policies.

Recommendation 5: Consider and evaluate the potential use of economic instruments such as user taxes, flood insurance and the user pay principal, rather than relying solely on regulatory approaches which have not always been effective.

4.1.6 Co-operative Alliances

There are various opportunities for co-operative alliances to reduce flood risk and damage, which should be identified and pursued. Floodplain management strategies that enlist the co-operation of the banking, real estate and insurance industries is just one example that may prove beneficial for reducing flood damage potential. Since all property owners are involved with these industries to some degree (e.g., mortgages, purchasing and selling, and loss coverage), they may be influential in deterring people from occupying or developing flood prone lands. The benefits of these sorts of co-operative alliances have not been fully taken advantage of in Canada. For example, providing information about the likely hazards associated with a particular property during real estate transactions could better inform residents and promote a culture of preparedness. Shrubsole and Scherer (1996) examined the perceptions of home mortgage lenders, real estate agents and land appraisers in portions of the Grand River watershed, Ontario, to floodplain regulations. They found that although formal training pertaining to floods and regulations was limited, the real estate sector was aware of the need to disclose this type of information to prospective buyers. This however was pursued in neither an effective nor consistent manner. Potential purchasers were often provided this information late in the purchase process but prior to an offer to purchase, which detracts from its effectiveness. Information about the flood hazard was also available to homebuyers during their title search since Ontario conservation authorities had frequently applied a title notice and/or a release as a condition of development in flood prone areas. However, the purchaser's lawyer would communicate this information after the offer to purchase had been made, so the purchaser may already feel committed to finalize the deal. Mandatory and early disclosure required in the United States could therefore serve as a model in Canada (Platt, 1999).

Recommendation 6: Expand the community involved in flood risk management to private sector agencies such as banking, real estate, and insurance industries (by mandatory disclosure of flood risk through mortgages and property deeds and flood insurance).

or developing without adequate floodproofing, which has not been the case in the past. The loss of eligibility to DFAA would also be another economic instrument that would encourage regulation of development in high flood risk areas. The economic instruments discussed here would be a drastic change from the current practice in Canada where the costs for flood disasters or prevention are generally spread among society including those not gaining any benefit from flood prone lands. It is also important to note that any implemented economic program must be affordable to both government and the general person. These programs should also not create severe hardship to those that already residing in flood risk areas or vulnerable or disadvantaged people. For this reason it would be necessary to study the feasibility of implementing these economic strategies and the ability of government to strictly stand by their policies.

Recommendation 5: Consider and evaluate the potential use of economic instruments such as user taxes, flood insurance and the user pay principal, rather than relying solely on regulatory approaches which have not always been effective.

4.1.6 Co-operative Alliances

There are various opportunities for co-operative alliances to reduce flood risk and damage, which should be identified and pursued. Floodplain management strategies that enlist the co-operation of the banking, real estate and insurance industries is just one example that may prove beneficial for reducing flood damage potential. Since all property owners are involved with these industries to some degree (e.g., mortgages, purchasing and selling, and loss coverage), they may be influential in deterring people from occupying or developing flood prone lands. The benefits of these sorts of co-operative alliances have not been fully taken advantage of in Canada. For example, providing information about the likely hazards associated with a particular property during real estate transactions could better inform residents and promote a culture of preparedness. Shrubsole and Scherer (1996) examined the perceptions of home mortgage lenders, real estate agents and land appraisers in portions of the Grand River watershed, Ontario, to floodplain regulations. They found that although formal training pertaining to floods and regulations was limited, the real estate sector was aware of the need to disclose this type of information to prospective buyers. This however was pursued in neither an effective nor consistent manner. Potential purchasers were often provided this information late in the purchase process but prior to an offer to purchase, which detracts from its effectiveness. Information about the flood hazard was also available to homebuyers during their title search since Ontario conservation authorities had frequently applied a title notice and/or a release as a condition of development in flood prone areas. However, the purchaser's lawyer would communicate this information after the offer to purchase had been made, so the purchaser may already feel committed to finalize the deal. Mandatory and early disclosure required in the United States could therefore serve as a model in Canada (Platt, 1999).

Recommendation 6: Expand the community involved in flood risk management to private sector agencies such as banking, real estate, and insurance industries (by mandatory disclosure of flood risk through mortgages and property deeds and flood insurance).

4.1.7 Information and Education

Concern over the inability of people to perceive their vulnerability to flooding has been raised repeatedly (McKay, 1996; Ministry of Natural Resources, 1977). Lack of awareness of the flood problem may limit the success of policies and programs to reduce damages. Education and outreach are therefore vital aspects of informing: the general public, elected representatives and staff of all levels of government, managers and decision makers of private sector companies, Crown Corporations and utilities; individuals and professionals associations (e.g., developers, architects, real estate agents, planners, engineers, building inspectors, lawyers, insurers and mortgage institutions); and nongovernmental and volunteer organizations. The economic, social and environmental costs of flooding as well as the cost-benefit of flood protection measures need to be clearly articulated in "plain-language" materials that are widely available and disseminated. The goal should be to slowly change perceptions of development and settlement in high flood risk areas or behind structural works. Effective educational and communication tools should be developed and used to ensure that information and education play a key role in minimizing flood risk and damages.

An informed citizen is needed if a change in the public's responsibility and accountability towards flood hazards is to be obtained. The involvement and participation of the public is important in the decision-making processes of flood mitigation, as seen after the 1997 Red River flood. Minimal public participation in the emergency decision-making process during this flood resulted in limited success of a considerable amount of organizational preparedness and mobilization (Haque, Forthcoming). Sufficient public involvement is also necessary to ensure that the communities' needs are being met and their voices are heard. In addition, educational tools should be developed for use in outreach activities as well as lobbying for political and public support. The effectiveness of some of these tools would benefit from a visual component, key case study examples, and "what if" scenarios.

Recommendation 7: Strengthen public education and build greater awareness at all levels (public, private, government, and non-government) that are involved in flooding issues.

4.1.8 Resilient Communities

"Canadian taxpayers... are now spending on average $500 million a year in responding to helping people recover when a disaster hits... [and] it only makes great sense that we should spend some money to make these communities less vulnerable (Anderson, 1999)." Building resilient communities is another investment that can reduce future losses from flood hazards. Various criteria can contribute to flood resiliency such as: the removal of buildings or structures on the floodplain; improved flood protection for buildings remaining in the floodplain; faster recovery after future flood events; promoting individual and community self-sufficiency and responsibility; promoting flood insurance; enhancing community livelihood, environmental quality, or quality of life; and providing for mitigation (Natural Hazards Center, University of Colorado and Disaster Research Institute, University of Manitoba, 1999).

The social and psychological resiliency is largely related to the state and nature of social capital (i.e., organizational and decision making capacity and the type of economic and industrial base at the local level). A post-1997 Red River flood study revealed that communities characterized by higher levels of physical, human and social capital were better-prepared and more effective responders to the flood (Buckland and Rahman, 1999). Similarly, communities with diverse, vibrant and dynamic economic base and organizations exhibited better resiliency than communities with limited employment and less support services. In order to increase community resiliency where it is lacking most, investment in enhancing economic, human and social capital, through local level organizational and decision making capacity building, should be seriously considered. In such efforts, attempts could be made to develop partnerships between the national, provincial and local level institutions, including public sector and non-governmental organizations, to optimize resources and obtain desired results.

Flood damages could be reduced effectively by increasing community resiliency, which could be significantly increased by relocating structures and other floodproofing measures. Removal of structures and buildings from floodplains however, should ensure that rebuilding does not occur. Permanent removal could occur through buyouts of flood-damaged property, as done in the United States where recovery assistance has been used to remove hundreds of structures from floodplains (Natural Hazards Center, University of Colorado and Disaster Research Institute, University of Manitoba, 1999). Buyouts and relocation of properties have been a component of the extensive floodproofing that has taken place in Manitoba following the 1997 flood. In addition to removing structures through buyouts, there could be federal-provincial incentives offered for moving structures out of the flood-prone area and for other floodproofing (such as raising buildings). While the cost of relocation may be high and considered drastic, in the United States the savings have shown to be well worth the investment. For example, for every US $1 spent on relocation by the Federal Emergency Management Agency (FEMA) hazard mitigation program, US $2 is saved in disaster relief (Schildgen, 1999).

Recommendation 8: Strengthen community resiliency where it is lacking the most.

4.2 Research

One of the salient points to emerge from the meeting was the need for further research to improve the understanding of the flood problem and provide better information for forming or strengthening institutional and policy environments to adequately deal with reducing flood damage and hazard. The areas suggested for further research are covered below.

4.2.1 Flood Impacts

The Panel recommended increasing the knowledge of flood impacts. This would include assessments of the direct and indirect social, economic and environmental impacts of flooding to provide a greater understanding of the cost-benefits of reducing flood hazards. Further research may also identify important flood impacts to society, which could serve as a tool for educating people about the hazard and assist in developing future flood programs and policies.

4.1.7 Information and Education

Concern over the inability of people to perceive their vulnerability to flooding has been raised repeatedly (McKay, 1996; Ministry of Natural Resources, 1977). Lack of awareness of the flood problem may limit the success of policies and programs to reduce damages. Education and outreach are therefore vital aspects of informing: the general public, elected representatives and staff of all levels of government, managers and decision makers of private sector companies, Crown Corporations and utilities; individuals and professionals associations (e.g., developers, architects, real estate agents, planners, engineers, building inspectors, lawyers, insurers and mortgage institutions); and nongovernmental and volunteer organizations. The economic, social and environmental costs of flooding as well as the cost-benefit of flood protection measures need to be clearly articulated in "plain-language" materials that are widely available and disseminated. The goal should be to slowly change perceptions of development and settlement in high flood risk areas or behind structural works. Effective educational and communication tools should be developed and used to ensure that information and education play a key role in minimizing flood risk and damages.

An informed citizen is needed if a change in the public's responsibility and accountability towards flood hazards is to be obtained. The involvement and participation of the public is important in the decision-making processes of flood mitigation, as seen after the 1997 Red River flood. Minimal public participation in the emergency decision-making process during this flood resulted in limited success of a considerable amount of organizational preparedness and mobilization (Haque, Forthcoming). Sufficient public involvement is also necessary to ensure that the communities' needs are being met and their voices are heard. In addition, educational tools should be developed for use in outreach activities as well as lobbying for political and public support. The effectiveness of some of these tools would benefit from a visual component, key case study examples, and "what if" scenarios.

Recommendation 7: Strengthen public education and build greater awareness at all levels (public, private, government, and non-government) that are involved in flooding issues.

4.1.8 Resilient Communities

"Canadian taxpayers… are now spending on average $500 million a year in responding to helping people recover when a disaster hits… [and] it only makes great sense that we should spend some money to make these communities less vulnerable (Anderson, 1999)." Building resilient communities is another investment that can reduce future losses from flood hazards. Various criteria can contribute to flood resiliency such as: the removal of buildings or structures on the floodplain; improved flood protection for buildings remaining in the floodplain; faster recovery after future flood events; promoting individual and community self-sufficiency and responsibility; promoting flood insurance; enhancing community livelihood, environmental quality, or quality of life; and providing for mitigation (Natural Hazards Center, University of Colorado and Disaster Research Institute, University of Manitoba, 1999).

The social and psychological resiliency is largely related to the state and nature of social capital (i.e., organizational and decision making capacity and the type of economic and industrial base at the local level). A post-1997 Red River flood study revealed that communities characterized by higher levels of physical, human and social capital were better-prepared and more effective responders to the flood (Buckland and Rahman, 1999). Similarly, communities with diverse, vibrant and dynamic economic base and organizations exhibited better resiliency than communities with limited employment and less support services. In order to increase community resiliency where it is lacking most, investment in enhancing economic, human and social capital, through local level organizational and decision making capacity building, should be seriously considered. In such efforts, attempts could be made to develop partnerships between the national, provincial and local level institutions, including public sector and non-governmental organizations, to optimize resources and obtain desired results.

Flood damages could be reduced effectively by increasing community resiliency, which could be significantly increased by relocating structures and other floodproofing measures. Removal of structures and buildings from floodplains however, should ensure that rebuilding does not occur. Permanent removal could occur through buyouts of flood-damaged property, as done in the United States where recovery assistance has been used to remove hundreds of structures from floodplains (Natural Hazards Center, University of Colorado and Disaster Research Institute, University of Manitoba, 1999). Buyouts and relocation of properties have been a component of the extensive floodproofing that has taken place in Manitoba following the 1997 flood. In addition to removing structures through buyouts, there could be federal-provincial incentives offered for moving structures out of the flood-prone area and for other floodproofing (such as raising buildings). While the cost of relocation may be high and considered drastic, in the United States the savings have shown to be well worth the investment. For example, for every US $1 spent on relocation by the Federal Emergency Management Agency (FEMA) hazard mitigation program, US $2 is saved in disaster relief (Schildgen, 1999).

Recommendation 8: Strengthen community resiliency where it is lacking the most.

4.2 Research

One of the salient points to emerge from the meeting was the need for further research to improve the understanding of the flood problem and provide better information for forming or strengthening institutional and policy environments to adequately deal with reducing flood damage and hazard. The areas suggested for further research are covered below.

4.2.1 Flood Impacts

The Panel recommended increasing the knowledge of flood impacts. This would include assessments of the direct and indirect social, economic and environmental impacts of flooding to provide a greater understanding of the cost-benefits of reducing flood hazards. Further research may also identify important flood impacts to society, which could serve as a tool for educating people about the hazard and assist in developing future flood programs and policies.

In particular, the study of the ecological impacts of flood control structures was suggested. Dams, reservoirs, channel adjustments and water diversions are examples of these types of structures. Due to their grand scale and/or alterations to the landscape they can drastically alter the river ecosystem in addition to the hydrological cycle. As a result, structural measures can impact ecologically sensitive habit. Hunt (1999) noted several impacts of dam and levee construction that severely altered riverine environments or disrupted aquatic ecology and organisms along the river system. These ecosystem issues must be resolved through the research of new structural designs, operational procedures, and management approaches for any area that require flood infrastructure in order to protect lives and property in addition to the natural environment.

In addition, there is a need for better data and understanding of flood damages, risks and vulnerability. Risk assessments or analyses of flood events could collect a variety of information regarding flood impacts and data. "Risk assessment is a rigorous form of assessment that uses formal quantitative techniques to estimate probabilities of effects on well-defined end points, estimate uncertainties, and partitions analysis of risks from decision making concerning significance of risks and choice of actions (Sutter II, 1993)." The information collected could then be placed into a database or information repository that was widely available, such as the World Wide Web. This database would contain technical, socio-economic and environmental information for past flood events, including types of flood mitigation measures taken (their advantages and disadvantages, and costs versus benefits etc.). The database would be beneficial in summarizing and disseminating the knowledge of flood impacts. It would also provide data that could be compared to assess flood impacts in comparison to various flood mitigative options.

Recommendation 9: Improve the knowledge of impacts (including socio- economic and environmental impacts) and the quality of data.

4.2.2 Assessments of Programs and Policies

Another important area of research involves expanding assessments or post-audits of implemented flood hazard reduction programs and policies. These studies could provide valuable information for future program or policy formulation. Suggestions were made on the type of research that should be conducted for these assessments. For instance, benefit-cost analysis (BCA) of flood measures is a practical, methodologically sound, and quantitative means to compare the benefits and costs of a particular project or program. It would assess if the benefits at least justify the costs and determine which project or program gave the best ratio of benefits to costs, or the greatest net benefit or both (Maniate and Carter, 1973). The strength of these sorts of studies is that the economic argument could be made quite compelling since the amount of costs averted and the benefits accrued could be clearly identified. As mentioned in section 3.5.3 *(Future Flood Damage Reduction Studies)* there are difficulties in identifying and quantifying all the benefits and costs in order to perform a comprehensive analysis. Nevertheless, this tool does provide a method of quantifying impacts and outcomes of measures taken to reduce and control flood hazards and for those costs and for benefits that cannot be quantified at least some

qualitative information can be provided. In addition, quantitative assessments of the effectiveness of flood damage reduction programs would assist in educating people of the benefits of proper management of floodplains.

Studies of effective versus ineffective flood hazard reduction programs and practices (including case studies) were also suggested. These could offer important insights as to why these programs worked or did not work. Also, existing mechanisms to direct individuals towards flood hazard reduction (such as flood insurance, mandatory disclosure of flood risk through mortgages and deeds, and flood risk development by-laws etc.) should be reviewed. Learning from these experiences would be helpful and the information could be adapted to areas of similar characteristics in order to determine the best approach to deal with existing flood hazards.

Recommendation 10: Expand post-audits of flood disasters to improve effectiveness of past mitigation activities and assist in future policies, programs or activities to deal with floods.

4.2.3 Risk-Taking and First Responders' Behaviour

Currently, in Canada, little is known about flood risk perception and risk-taking behaviour, or the flood risk and damage mitigation measures taken at the individual or household level. How individuals and communities in flood risk areas perceive a flood threat and what risks they are willing to take is not clearly understood. There has also been very little research done with respect to patterns in first responder's (i.e., individual) behaviour in flood hazard risk mitigation and response. These are areas that require attention since the responsibilities of dealing with floods are being directed away from higher-level governments towards the community and individual level. With greater importance placed upon the local and individual level it is recommended that in-depth research takes place to understand and model household and other pertinent unit level (such as community and local) risk-taking behaviour and mitigation measures towards floods. In addition, this type of research could assist in determining what individuals and communities are willing to undertake and do in order to mitigate flood risk and damages (such as their willingness to participate in and the feasibility of a flood insurance scheme) and enable more effective approaches in regards to information delivery to end-users.

Recommendation 11: Study flood risk-taking behaviour and the flood hazard risk mitigation and response behaviour of communities and individuals in high flood risk areas.

4.3 Institutional and Policy Environments

Flood management in Canada has evolved from being largely focused on structural solutions to one of greater floodplain management involving a mix of structural and non-structural solutions through the Flood Damage Reduction Program. In the mid-1990s, however, the federal government withdrew from the FDRP leading to its termination. In light of the FDRP's expiration and continued flood disasters, the Panel made recommendations for the creation of a

In particular, the study of the ecological impacts of flood control structures was suggested. Dams, reservoirs, channel adjustments and water diversions are examples of these types of structures. Due to their grand scale and/or alterations to the landscape they can drastically alter the river ecosystem in addition to the hydrological cycle. As a result, structural measures can impact ecologically sensitive habit. Hunt (1999) noted several impacts of dam and levee construction that severely altered riverine environments or disrupted aquatic ecology and organisms along the river system. These ecosystem issues must be resolved through the research of new structural designs, operational procedures, and management approaches for any area that require flood infrastructure in order to protect lives and property in addition to the natural environment.

In addition, there is a need for better data and understanding of flood damages, risks and vulnerability. Risk assessments or analyses of flood events could collect a variety of information regarding flood impacts and data. "Risk assessment is a rigorous form of assessment that uses formal quantitative techniques to estimate probabilities of effects on well-defined end points, estimate uncertainties, and partitions analysis of risks from decision making concerning significance of risks and choice of actions (Sutter II, 1993)." The information collected could then be placed into a database or information repository that was widely available, such as the World Wide Web. This database would contain technical, socio-economic and environmental information for past flood events, including types of flood mitigation measures taken (their advantages and disadvantages, and costs versus benefits etc.). The database would be beneficial in summarizing and disseminating the knowledge of flood impacts. It would also provide data that could be compared to assess flood impacts in comparison to various flood mitigative options.

Recommendation 9: Improve the knowledge of impacts (including socio- economic and environmental impacts) and the quality of data.

4.2.2 Assessments of Programs and Policies

Another important area of research involves expanding assessments or post-audits of implemented flood hazard reduction programs and policies. These studies could provide valuable information for future program or policy formulation. Suggestions were made on the type of research that should be conducted for these assessments. For instance, benefit-cost analysis (BCA) of flood measures is a practical, methodologically sound, and quantitative means to compare the benefits and costs of a particular project or program. It would assess if the benefits at least justify the costs and determine which project or program gave the best ratio of benefits to costs, or the greatest net benefit or both (Maniate and Carter, 1973). The strength of these sorts of studies is that the economic argument could be made quite compelling since the amount of costs averted and the benefits accrued could be clearly identified. As mentioned in section 3.5.3 *(Future Flood Damage Reduction Studies)* there are difficulties in identifying and quantifying all the benefits and costs in order to perform a comprehensive analysis. Nevertheless, this tool does provide a method of quantifying impacts and outcomes of measures taken to reduce and control flood hazards and for those costs and for benefits that cannot be quantified at least some

qualitative information can be provided. In addition, quantitative assessments of the effectiveness of flood damage reduction programs would assist in educating people of the benefits of proper management of floodplains.

Studies of effective versus ineffective flood hazard reduction programs and practices (including case studies) were also suggested. These could offer important insights as to why these programs worked or did not work. Also, existing mechanisms to direct individuals towards flood hazard reduction (such as flood insurance, mandatory disclosure of flood risk through mortgages and deeds, and flood risk development by-laws etc.) should be reviewed. Learning from these experiences would be helpful and the information could be adapted to areas of similar characteristics in order to determine the best approach to deal with existing flood hazards.

Recommendation 10: Expand post-audits of flood disasters to improve effectiveness of past mitigation activities and assist in future policies, programs or activities to deal with floods.

4.2.3 Risk-Taking and First Responders' Behaviour

Currently, in Canada, little is known about flood risk perception and risk-taking behaviour, or the flood risk and damage mitigation measures taken at the individual or household level. How individuals and communities in flood risk areas perceive a flood threat and what risks they are willing to take is not clearly understood. There has also been very little research done with respect to patterns in first responder's (i.e., individual) behaviour in flood hazard risk mitigation and response. These are areas that require attention since the responsibilities of dealing with floods are being directed away from higher-level governments towards the community and individual level. With greater importance placed upon the local and individual level it is recommended that in-depth research takes place to understand and model household and other pertinent unit level (such as community and local) risk-taking behaviour and mitigation measures towards floods. In addition, this type of research could assist in determining what individuals and communities are willing to undertake and do in order to mitigate flood risk and damages (such as their willingness to participate in and the feasibility of a flood insurance scheme) and enable more effective approaches in regards to information delivery to end-users.

Recommendation 11: Study flood risk-taking behaviour and the flood hazard risk mitigation and response behaviour of communities and individuals in high flood risk areas.

4.3 Institutional and Policy Environments

Flood management in Canada has evolved from being largely focused on structural solutions to one of greater floodplain management involving a mix of structural and non-structural solutions through the Flood Damage Reduction Program. In the mid-1990s, however, the federal government withdrew from the FDRP leading to its termination. In light of the FDRP's expiration and continued flood disasters, the Panel made recommendations for the creation of a

comprehensive flood mitigation program or policy. While the form of such a program is beyond the scope of the Panel, it is clear that it would require strengthening of existing programs and policies which have proven to be successful and also institutional innovations involving new federal mandates and renewed cooperation arrangements with the provincial governments. Some elements that should be incorporated or considered include: taking an integrated ecosystem approach towards flooding; ensuring increased public and governmental responsibilities and involvement; redesigning disaster assistance; and considering a new mitigation strategy.

4.3.1 Integrated Ecosystem Approach

The Panel recommended incorporating aspects of an integrated ecosystem approach for flood management. This would include best management practices to promote adaptation to floods, reduction of flood hazards, as well as, the maintenance or enhancement of natural and ecological benefits associated with flooding. The consideration and research of a suite of various factors affected by flooding will be necessary such as: those that deal with human loss, property damage and suffering; watershed biology (benefits and impacts); natural attributes of the ecosystem; and importantly, impacts on water quality (potable and environmental). If the expertise or financial requirements are not available at the provincial or local level to undertake these new studies outside assistance may be required. Under an ecosystem approach "floodplains are viewed not just as hazardous areas for settlement and use, but integrated ecological systems whose land and water resources are used by human benefits, despite the inherent flood hazard (Hooper and Duggin, 1996)."

This approach to flood management is not entirely new. Ontario conservation authorities for example have managed flood hazards by addressing the cumulative impacts of land use activities and changes on natural processes, and the functions and related social and economic impacts on a watershed basis (Veale *et al.*, 1997). The Grand River Conservation Authority has begun a broader integrated ecosystem approach to flooding with a recently completed GIS project defining a hazard line for the entire watershed using the following thematic map layers: drainage; floodlines; wetlands; slopes; poorly drained soils; other conservation lands; and erosion and buffer setbacks (as more information and databases become available they are added). This information is being used by GRCA planners and for incorporation into municipalities' official plans.

Examples, of an ecosystem approach to flooding can be found elsewhere in the world as well. Hunt (1999), in the United States, has identified that a "whole-system approach that takes the river channel, floodplain, and catchment into account; the maintenance of natural hydrological and ecological process of project design and implementation; and an adaptive approach to project management that allows management activities to change in response to new information or changing social or environmental conditions" is being adopted. There are several benefits to adopting this broader ecological approach or integrated approach in dealing with floods: both the costs and benefits of system improvement are spread more evenly throughout the river basin; the strategy builds upon a wider range of approaches and components, which is more robust than a single component approach; and the management of the river basin as an interconnected unit provides other co-benefits such as improved water quality, increased habitats, greater natural water storage etc. (Hunt, 1999). A review of literature from Australia, United Kingdom, and

United States, by de Loë (Forthcoming), also highlights an integrated or ecosystem management approach towards flooding. These reviewed studies identify that flooding is increasingly being addressed in the context of land use planning which considers a broader ecological perspective and ecosystem functions rather than simply on hydraulic considerations in these areas.

Recommendation 12: Flood management and mitigation programs should incorporate an integrated ecosystem approach.

4.3.2 Responsibility / Liability and Involvement

Recommendations that ensured increased responsibility, in conjunction with liability, and involvement of individuals and organizations involved in flood events were also made.

As past lessons have shown, the effectiveness of programs to deal with flood hazards may be limited if they are not adhered to, such as in the case of municipalities permitting increased occupancy in designated flood risk areas (Kreutzwiser, 1988; Shrubsole *et al.*, 1995; Shrubsole *et al.*, 1997; Morris-Oswald *et al.*, 1998; Forget *et al.*, 1999). There should be a broadening of municipality and individual responsibilities to include or strengthen their roles in floodplain management and flood hazard mitigation. This is important especially since the federal government has reduced its involvement in flood management and to also ensure greater cost sharing by people who are actually benefiting from residing or developing in flood prone areas. This increased responsibility must be accompanied by increased liability or accountability (such as through the use of insurance ratings or higher levels before federal / provincial assistance is available) or else there may not be sufficient penalty for not adhering to flood damage reduction programs. In addition, clear, effective, and appropriate sharing of responsibilities should be presented to the parties involved, which ensures a cooperative effort so that there is no fragmentation or overlap of these responsibilities. Placing greater emphasis on the role of municipalities, local governments, and individuals would help foster mitigation at the local level.

However, responsibilities at the local level cannot simply be increased without any support from the provincial and federal governments. de Loë (Forthcoming) has identified two concerns relating to the variable capacity and commitment of provinces and municipalities under declining support for flood mitigation. The worst-case situation could result in provincial governments abandoning the principals underlying the FDRP and even if that did not occur the capacity of smaller provinces to carry on alone would be hindered since they rely on federal technical and financial assistance more so than provinces such as Ontario, Alberta, and British Columbia. The absence of a strong provincial commitment may make it difficult for municipalities to reject development in flood risk areas or conversely municipalities may loosen development restrictions to encourage local economic development. In addition, a lack of technical and financial support would make it even more difficult to conduct necessary studies (such as complete watershed studies) if an ecosystem approach to flood management is to be implemented since municipalities, especially smaller ones, are under tight financial pressures (de Loë, Forthcoming).

United States, by de Loë (Forthcoming), also highlights an integrated or ecosystem management approach towards flooding. These reviewed studies identify that flooding is increasingly being addressed in the context of land use planning which considers a broader ecological perspective and ecosystem functions rather than simply on hydraulic considerations in these areas.

Recommendation 12: Flood management and mitigation programs should incorporate an integrated ecosystem approach.

4.3.2 Responsibility / Liability and Involvement

Recommendations that ensured increased responsibility, in conjunction with liability, and involvement of individuals and organizations involved in flood events were also made.

As past lessons have shown, the effectiveness of programs to deal with flood hazards may be limited if they are not adhered to, such as in the case of municipalities permitting increased occupancy in designated flood risk areas (Kreutzwiser, 1988; Shrubsole *et al.*, 1995; Shrubsole *et al.*, 1997; Morris-Oswald *et al.*, 1998; Forget *et al.*, 1999). There should be a broadening of municipality and individual responsibilities to include or strengthen their roles in floodplain management and flood hazard mitigation. This is important especially since the federal government has reduced its involvement in flood management and to also ensure greater cost sharing by people who are actually benefiting from residing or developing in flood prone areas. This increased responsibility must be accompanied by increased liability or accountability (such as through the use of insurance ratings or higher levels before federal / provincial assistance is available) or else there may not be sufficient penalty for not adhering to flood damage reduction programs. In addition, clear, effective, and appropriate sharing of responsibilities should be presented to the parties involved, which ensures a cooperative effort so that there is no fragmentation or overlap of these responsibilities. Placing greater emphasis on the role of municipalities, local governments, and individuals would help foster mitigation at the local level.

However, responsibilities at the local level cannot simply be increased without any support from the provincial and federal governments. de Loë (Forthcoming) has identified two concerns relating to the variable capacity and commitment of provinces and municipalities under declining support for flood mitigation. The worst-case situation could result in provincial governments abandoning the principals underlying the FDRP and even if that did not occur the capacity of smaller provinces to carry on alone would be hindered since they rely on federal technical and financial assistance more so than provinces such as Ontario, Alberta, and British Columbia. The absence of a strong provincial commitment may make it difficult for municipalities to reject development in flood risk areas or conversely municipalities may loosen development restrictions to encourage local economic development. In addition, a lack of technical and financial support would make it even more difficult to conduct necessary studies (such as complete watershed studies) if an ecosystem approach to flood management is to be implemented since municipalities, especially smaller ones, are under tight financial pressures (de Loë, Forthcoming).

Public involvement and consultation should be ensured in the implementing of management strategies for flood hazards. Community involvement may require providing sufficient education on flood hazards, damages, and impacts. This will increase the understanding of the problem and convince the public to participate or buy-into actions and decisions to reduce flood hazards. Sufficient public involvement is necessary to ensure that the communities' needs are being met and their voices heard. In addition, public participation should ensure that all levels of society have a voice or are represented equally. There is considerable variability among the public because of different cultures, demographics and income levels in Canada. An example of discrepancy in decision-making power can be seen in Manitoba. Reeves and mayors have legal authority to declare a flood emergency, but there is no legislative recognition of a First Nations' chief and council's authority in the governance of Manitoba reserves (Haque, Forthcoming). Other vulnerabilities may also exist with the elderly who may not be able to respond to emergency flood situations or low-income individuals that may not be able to afford appropriate floodproofing or relocation etc. Therefore, it is important that these vulnerable groups are well represented and involved in decisions regarding flood hazard reduction.

Recommendation 13: Strengthen individual, community, and municipal responsibility and capacity in floodplain management and flood hazard mitigation.

4.3.3 Redefining Disaster Assistance

Since it is impossible to eliminate all flood hazards as long as people and property occupy flood prone areas, disaster assistance programs should be reconstructed or redirected towards loss-reduction and mitigation. This will ensure that this assistance provides the greatest benefit and reduction of future flood losses rather than simply being used to rebuild damaged property in flood prone areas. It was recommended that a portion (15%) of disaster financial assistance be dedicated towards mitigation. This percentage is similar to one of the recommendations made by Canada's insurers in the National Mitigation Strategy proposal, which will be discussed in the following section 4.3.4 *(National Mitigation Strategy)*. This 15% of DFAA directed towards mitigation could also be more flexible and revaluated on a case-by-case basis.

In addition, there should greater consideration of the policy of not providing disaster assistance for any development built after an area is designated as a flood risk area unless it is on the flood fringe and has been adequately floodproofed. This is one aspect of the Flood Damage Reduction Program that has not always been followed very well (Day, 1999). DFAA payments may also be limited in regards to the number of times compensation is paid out. So long as the federal government continues to pay disaster assistance to those who continue development or do not adequately floodproof structures, there will be less incentive to reduce future flood hazards. It should be made clear that flood damage assistance will be withheld for new development in identified flood risk areas or for those who have not implemented sufficient floodproofing.

Recommendation 14: Revise the Disaster Financial Assistance Arrangement program to allow a flexible portion available for mitigation activities. Also, consider withholding DFAA payments for new development in high-risk zones or repeated claims.

4.3.4 National Mitigation Strategy

The Panel reviewed the need for leadership in the promotion of a new policy on flood mitigation, based on the knowledge and assessments of past programs to date. A new national mitigation strategy is recommended in order to deal with floods and other natural hazards. However, since an integrated national strategy may be difficult to attain due to the regional differences or will be so general that it will be of no practical value, it is suggested that a careful approach with serious regional discussion is required.

There is some support for the current plan of the insurance community of Canada, the Institute for Catastrophic Loss Reduction (ICLR), in cooperation with Emergency Preparedness Canada, to champion the creation of a national mitigation strategy. This new policy would invest in actions to improve Canadian resilience to extreme weather and earthquakes (Insurance Bureau of Canada, 1999). No such program in Canada exists today to provide leadership and funding for mitigation programs and measures and therefore the recent work into the beginnings of this program have been suggested (Natural Hazards Center, University of Colorado and Disaster Research Institute, University of Manitoba, 1999). The Natural Disaster Reduction Plan as proposed in a report from Insurance Bureau of Canada (IBC) includes three elements:

- The three levels of government have been asked to contribute $750 million dollars over the next five years to create a Natural Disaster Protection Fund. The framework could be similar to the "Canada Works" infrastructure program introduced by the current federal government and ran from 1993 to 1997 with specific initiatives that came from the local level and all three levels of government shared the costs.

- Augment the existing Disaster Financial Assistance Arrangements by an amount equal to 15% of the post-disaster clean-up cost. This would mean that in response to a flood, for example, an extra 15 cents of each dollar could be spent on measures to prevent that flood from happening again or mitigating the effects if it does reoccur. ICLR's November 1998 public opinion poll conducted by Pollara of 1,600 Canadians revealed that almost 90% of the sample believes that disaster prevention spending should be a priority for governments. On average, they also believed that governments should spend $1 on risk reduction for every dollar they spend on response and recovery, an amount well over the 15% proposed.

- Canadians need to create a culture of preparedness. We need to start thinking about the risks we face and mitigate or lessen the impact. If we allow development on floodplains, how often do we want to pay to keep rebuilding it? All levels of government should make disaster preparedness a cornerstone of government policy by requiring that future public projects include an analysis on how the projects will make Canada's communities more resilient to future natural disasters.

Public involvement and consultation should be ensured in the implementing of management strategies for flood hazards. Community involvement may require providing sufficient education on flood hazards, damages, and impacts. This will increase the understanding of the problem and convince the public to participate or buy-into actions and decisions to reduce flood hazards. Sufficient public involvement is necessary to ensure that the communities' needs are being met and their voices heard. In addition, public participation should ensure that all levels of society have a voice or are represented equally. There is considerable variability among the public because of different cultures, demographics and income levels in Canada. An example of discrepancy in decision-making power can be seen in Manitoba. Reeves and mayors have legal authority to declare a flood emergency, but there is no legislative recognition of a First Nations' chief and council's authority in the governance of Manitoba reserves (Haque, Forthcoming). Other vulnerabilities may also exist with the elderly who may not be able to respond to emergency flood situations or low-income individuals that may not be able to afford appropriate floodproofing or relocation etc. Therefore, it is important that these vulnerable groups are well represented and involved in decisions regarding flood hazard reduction.

Recommendation 13: Strengthen individual, community, and municipal responsibility and capacity in floodplain management and flood hazard mitigation.

4.3.3 Redefining Disaster Assistance

Since it is impossible to eliminate all flood hazards as long as people and property occupy flood prone areas, disaster assistance programs should be reconstructed or redirected towards loss-reduction and mitigation. This will ensure that this assistance provides the greatest benefit and reduction of future flood losses rather than simply being used to rebuild damaged property in flood prone areas. It was recommended that a portion (15%) of disaster financial assistance be dedicated towards mitigation. This percentage is similar to one of the recommendations made by Canada's insurers in the National Mitigation Strategy proposal, which will be discussed in the following section 4.3.4 *(National Mitigation Strategy)*. This 15% of DFAA directed towards mitigation could also be more flexible and revaluated on a case-by-case basis.

In addition, there should greater consideration of the policy of not providing disaster assistance for any development built after an area is designated as a flood risk area unless it is on the flood fringe and has been adequately floodproofed. This is one aspect of the Flood Damage Reduction Program that has not always been followed very well (Day, 1999). DFAA payments may also be limited in regards to the number of times compensation is paid out. So long as the federal government continues to pay disaster assistance to those who continue development or do not adequately floodproof structures, there will be less incentive to reduce future flood hazards. It should be made clear that flood damage assistance will be withheld for new development in identified flood risk areas or for those who have not implemented sufficient floodproofing.

Recommendation 14: Revise the Disaster Financial Assistance Arrangement program to allow a flexible portion available for mitigation activities. Also, consider withholding DFAA payments for new development in high-risk zones or repeated claims.

4.3.4 National Mitigation Strategy

The Panel reviewed the need for leadership in the promotion of a new policy on flood mitigation, based on the knowledge and assessments of past programs to date. A new national mitigation strategy is recommended in order to deal with floods and other natural hazards. However, since an integrated national strategy may be difficult to attain due to the regional differences or will be so general that it will be of no practical value, it is suggested that a careful approach with serious regional discussion is required.

There is some support for the current plan of the insurance community of Canada, the Institute for Catastrophic Loss Reduction (ICLR), in cooperation with Emergency Preparedness Canada, to champion the creation of a national mitigation strategy. This new policy would invest in actions to improve Canadian resilience to extreme weather and earthquakes (Insurance Bureau of Canada, 1999). No such program in Canada exists today to provide leadership and funding for mitigation programs and measures and therefore the recent work into the beginnings of this program have been suggested (Natural Hazards Center, University of Colorado and Disaster Research Institute, University of Manitoba, 1999). The Natural Disaster Reduction Plan as proposed in a report from Insurance Bureau of Canada (IBC) includes three elements:

- The three levels of government have been asked to contribute $750 million dollars over the next five years to create a Natural Disaster Protection Fund. The framework could be similar to the "Canada Works" infrastructure program introduced by the current federal government and ran from 1993 to 1997 with specific initiatives that came from the local level and all three levels of government shared the costs.

- Augment the existing Disaster Financial Assistance Arrangements by an amount equal to 15% of the post-disaster clean-up cost. This would mean that in response to a flood, for example, an extra 15 cents of each dollar could be spent on measures to prevent that flood from happening again or mitigating the effects if it does reoccur. ICLR's November 1998 public opinion poll conducted by Pollara of 1,600 Canadians revealed that almost 90% of the sample believes that disaster prevention spending should be a priority for governments. On average, they also believed that governments should spend $1 on risk reduction for every dollar they spend on response and recovery, an amount well over the 15% proposed.

- Canadians need to create a culture of preparedness. We need to start thinking about the risks we face and mitigate or lessen the impact. If we allow development on floodplains, how often do we want to pay to keep rebuilding it? All levels of government should make disaster preparedness a cornerstone of government policy by requiring that future public projects include an analysis on how the projects will make Canada's communities more resilient to future natural disasters.

The implementation of a national mitigation strategy could be of major benefit in dealing with floods and other natural hazards. Some of the benefits and outcomes would include: a more resilient and competitive Canadian economy; a reduction of future expenditures on disaster relief recovery; and a reduction in loss of life and social and economic disruption. This is one possible way of creating a culture of preparedness and disaster mitigation and should be considered.

Recommendation 15: Give careful consideration to the National Mitigation Strategy proposed by the Institute for Catastrophic Loss Reduction.

The implementation of a national mitigation strategy could be of major benefit in dealing with floods and other natural hazards. Some of the benefits and outcomes would include: a more resilient and competitive Canadian economy; a reduction of future expenditures on disaster relief recovery; and a reduction in loss of life and social and economic disruption. This is one possible way of creating a culture of preparedness and disaster mitigation and should be considered.

Recommendation 15: Give careful consideration to the National Mitigation Strategy proposed by the Institute for Catastrophic Loss Reduction.

Appendix A – Independent Expert Panel Members

Flood Mitigation Workshop December 15-16th, 1999 in Hull, Québec

The Independent Expert Panel

Jim Abraham, Dartmouth, Nova Scotia
Peter Anderson, Burnaby, British Columbia
Bill Appleby, Dartmouth, Nova Scotia
Greg Brooks, Ottawa, Ontario
Jim Bruce, Ottawa, Ontario
Ian Burton, Downsview, Ontario
John Cooper, Ottawa, Ontario
Chad Day, Burnaby, British Columbia
Rob de Loë, Guelph, Ontario
Christian Dufournaud, Waterloo, Ontario
David Etkin, Toronto, Ontario
Don Greer, Peterborough, Ontario
C. Emdad Haque, Brandon, Manitoba
Raimo Kallio, Ottawa, Ontario
Grace Koshida, Ottawa, Ontario
Reid Kreutzwiser, Guelph, Ontario
Ashij Kumar, Downsview, Ontario
Jacinthe Lacroix, Saint-Foy, Québec
Frank Millerd, Waterloo, Ontario
Syed Moin, Burlington, Ontario
John Newton, Toronto, Ontario
Kevin Pal, Toronto, Ontario
Alan Pang, Toronto, Ontario
Dave Peters, Manotick, Ontario
Paul Pilon, Guelph, Ontario
Jean Rousselle, Montreal, Québec
Joseph Scanlon, Ottawa, Ontario
Karl Schaefer, Burlington, Ontario
Dan Shrubsole, London, Ontario
Slobodan Simonovic, Winnipeg, Manitoba
Michel Slivitzky, Saint-Raymond, Québec
Robert Tait, Winnipeg, Manitoba
Chris Tucker, Ottawa, Ontario
Alfred Warkentin, Winnipeg, Manitoba

Appendix B – List of Participants from Flood Mitigation Workshop

Flood Mitigation Workshop December 15-16th, 1999 in Hull, Québec

List of Participants, Reviewers or Invitees

Workshop Committee

Ian Burton, Chair
Adaptation and Impacts Research Grp
Meteorological Service of Canada
Environment Canada
4905 Dufferin Street
Downsview, Ontario M3H 5T4
416 739 4314 (T)
416 739 4297 (F)
Ian.Burton@ec.gc.ca

David Etkin
Adaptation and Impacts Research Group
Environment Canada
c/o Institute for Environmental Studies
33 Willcocks Street
Toronto, Ontario M5S 3E8
416 978 6310 (T)
416 978 3884 (F)
David.Etkin@ec.gc.ca

Indra Fung Fook
Adaptation & Impacts Research Grp
Meteorological Service of Canada
Environment Canada
4905 Dufferin Street
Downsview, Ontario M3H 5T4
416 739 4436 (T)
416 739 4297 (F)
Indra.FungFook@ec.gc.ca

Ashij Kumar
Adaptation and Impacts Research Group
Meteorological Service of Canada
Environment Canada
4905 Dufferin Street
Downsview, Ontario M3H 5T4
416 739 4367 (T)
416 739 4297 (F)
Ashij.Kumar@ec.gc.ca

Independent Expert Panel

Jim Abraham
Meteorological Service of Canada
Environment Canada
45 Alderney Dr.
Dartmouth, Nova Scotia B2Y 2N6
902 426 9134 (T)
902 426 9158 (F)
Jim.Abraham@ec.gc.ca

Peter Anderson
School of Communication
Telematics Research Lab
Simon Fraser University
8888 University Drive
Burnaby, British Columbia V5A1S6
604 291 4921 (T)
604 291 4024 (F)
anderson@sfu.ca

Bill Appleby
Atmospheric Environment Branch
Environment Canada
45 Alderney Dr
Dartmouth, Nova Scotia B2Y 2N6
902 426 9120 (T)
902 426 9158 (F)
Bill.Appleby@ec.gc.ca

Greg Brooks
Geological Survey of Canada
Terrain Sciences Division
601 Booth St.
Ottawa, Ontario K1A 0E8
613 996 4548 or 613 992 2324 (T)
613 992 0190 (F)
gbrooks@gsc.nrcan.gc.ca

Jim Bruce
Canadian Policy Representative, Soil & Water Conservation Society
1875 Juno Avenue
Ottawa, Ontario K1H 6S6
416 731 5929 (T)
416 731 3509 (F)
jpbruce@sympatico.ca

John Cooper
Water Issues Branch
Environmental Conservation Service
Environment Canada
Ottawa, Ontario K1A 0H3
819 953 4007 (T)
819 994 0237 (F)
John.Cooper@ec.gc.ca

Alan Davenport
The Boundary Layer Wind Tunnel Laboratory
University of Western Ontario
Faculty of Engineering Science
London, Ontario N6A 5B9
519 661 3338 (T)
519 661 3339 (F)
agd@windy.blwtl.uwo.ca

Chad Day
Resource and Environmental Management
Simon Fraser University
Burnaby, British Columbia V5A1S6
604 291 3067 (T)
604 291 4968 (F)
jday@sfu.ca

Rob de Loë
Department of Geography
University of Guelph
Guelph, Ontario N1G 9Z9
519 824 4120 (T) ext. 3525
519 837 2940 (F)
rdeloe@uoguelph.ca

Ron diLabio
Geological Survey of Canada, Terrain Sciences Division
Natural Resources Canada
601 Booth Street, 3rd Floor, Rm361
Ottawa, Ontario K1A 0E8
613 992 1380 (T)
613 992 0190 (F)
rdilabio@NRCan.gc.ca

Christian Dufournaud
Department of Geography
Waterloo University
Waterloo, Ontario N2L 3G1
519 888 2068 (T)
cmdufour@fes.uwaterloo.ca

Grace Koshida
Emergency Preparedness Canada
Office of the Senior Scientific Advisor
122 Bank Street, 2nd floor
Jackson Building
Ottawa, Ontario K1A 0W6
613 991 7072 (T)
613 996 0995 (F)
Grace.Koshida@epc-pcc.gc.ca

John Newton
John Newton Associates
262 Robert St.
Toronto, Ontario M5C 2W7
416 929 3621 (T)
416 929 3621 (F)
jnewton@interlog.com

Wayne Greene
Health, Safety and Environment
University of British Columbia
Disaster Preparedness Resources Centre
2206 East Mall, 4th Floor
Vancouver, British Columbia V6T 1Z3
Canada
604 822 4218 (T)
604 822 6650 (F)
greene@safety.ubc.ca

Reid Kreutzwiser
Department of Geography
University of Guelph
Guelph, Ontario N1G 2W1
519 824-4120 (T) ext. 6720 or 6719
519 837 2940 (F)
reidk@geonet.css.uoguelph.ca

Kevin Pal
Environmental Services Insurers'
Advisory Organization
18 King Street E., Suite 700
Toronto, Ontario M5C 1C4
416 601 1801 (T)
kpal@iao.ca

Don Greer
Ministry of Natural Resources
5th Floor, South Tower
P.O. Box 7000,
300 Water Street,
Peterborough, Ontario K9J 8M5
705 755 1223 (T)
705 755 1201 (F)
don.greer@mnr.gov.on.ca

Jacinthe Lacroix
Services de l'expertise en securite civile
Gouvernement du Québec
Ministre de la Securite publique
2525, boul. Laurier, 6e etage
Saint-Foy, Québec G1V 2L2
418 646 3049 (T)
418 646 5427 (F)
jacinthe.lacroix@msp.gouv.qc.ca

Alan Pang
Institute for Catastrophic Loss Reduction
151 Yonge Street, Suite 1800
Toronto, Ontario M5C 2W7
416 362 2031 (T)
416 362 2602 (F)
apang@ibc.ca

C. Emdad Haque
Brandon University
Department of Geography
Environment & Resource Development
Brandon, Manitoba R7A 6AP
204 727 9770 (T)
204 728 7346 (F)
Haque@BrandonU.ca

David LeMarquand
IJC's International Red River Basin
Task Force
100 Metcalfe Street, Suite 203
Ottawa, Ontario K1P 5M1
613 995 9640 (T)
613 995 9644 (F)
lemarqua@achilles.net

Dave Peters
5413 Long Island Rd.,
Manotick, Ontario K4M 1H1
(613) 692-3144 (T)
(613) 692-1299 (F)
petersjd@cyberus.ca

Raimo Kallio
Water Issues Branch
Environmental Conservation Service
Environment Canada
Ottawa, Ontario K1A 0H3
819 997 2074 (T)
819 994 0237 (F)
Raimo.Kallio@ec.gc.ca

Frank Millerd
School of Business and Economics
Wilfrid Laurier University
75 University Avenue West
Waterloo, Ontario N2L 3C5
519 884 0710 (T) ext. 2037
519 888 1015 (F)
fmillerd@wlu.ca

Paul Pilon
Atmospheric Environment Branch
Environment Canada
75 Farquhar Street
Guelph, Ontario N1H 3N4
519 823 4202 (T)
519 826 2083 (F)
Paul.Pilon@ec.gc.ca

Bryan Karney
Department of Civil Engineering
University of Toronto
Galbraith Building, 35 St. George St.
Toronto, Ontario M5S 1A4
416 978 7776 (T)
416 978 6813 (F)
karney@civ.utoronto.ca

Syed Moin
Water Issues Division
Canadian Centre for Island Waters
(CCIW)
867 Lakeshore Road
Burlington, Ontario L7R 4A6
905 336 4958 (T)
905 336 8901 (F)
syed.moin@cciw.ca

Jean Rousselle
Hydrology and Water Resources
Department of Civil, Geological and
Mining Engineering (CGM)
P.O. Box 6079 Station Centre-Ville
Montreal, Québec H3C 3A7
514 340 4711 (T) ext. 4802
514 340 2989 (F)
Jrousselle@mail.polymtl.ca

Joseph Scanlon
Carleton University
School of Journalism
1125 Colonel by Drive, 3rd Floor
St. Patricks College
Ottawa, Ontario K1S 5B6
613 730 9239 (T)
613 730 1696 (F)
joe_scanlon@carleton.ca

Karl Schaefer
Great Lakes and Corporate Affairs Office
Environment Canada - Ontario Region
867 Lakeshore Road, PO Box 5050
Burlington, Ontario L7R 4A6
905 336 4950 (T)
905 336 8901 (F)
Karl.Schaefer@ec.gc.ca

Dan Shrubsole
Department of Geography
University of Western Ontario
London, Ontario N6A 5C2
519 661 2111 (T) ext. 85016
519 661 3750 (F)
dashrubs@julian.uwo.ca

Slobodan Simonovic
Natural Resources Institute
University of Manitoba
Winnipeg, Manitoba R3T 2N2
204 474 8375 (T)
204 261 0038 (F)
slobodan_simonovic@umanitoba.ca

Robert Tait
Disaster Research Institute Acting Director
University of Manitoba
212 Sinnott Building
Winnipeg, Manitoba R3T 2M6
204 474 8777 (T)
Rwtait@ms.umanitoba.ca

Chris Tucker
Emergency Preparedness Canada
Office of the Senior Scientific Advisor
122 Bank Street, 2nd floor
Jackson Building
Ottawa, Ontario K1A 0W6
613 991 7072 (T)
613 996 0995 (F)
Chris.Tucker@epc-pcc.gc.ca

Alfred Warkentin
Ministry of Natural Resources
Government of Manitoba
Water Resources Branch
Box 14, 200 Saulteaux Crescent
Winnipeg, Manitoba R3J 3W3
204 945 6396 (T)
awarkentin@nr.gov.mb.ca

Edgar Watt
Department of Civil Engineering
Ellis Hall
Queen's University
Kingston, Ontario K7L-3N6
613 545 2122 (T)
613 545 2128 (F)
watt@civil.queensu.ca

Senator Terry Stratton
Senate of Canada
Suite 902, Victoria Building
Parliament Buildings
Ottawa, Ontario K1A 0A4
613 947 2224 (T)
613 947 2226 (F)
Mulvaj@sen.parl.gc.ca
(Secretary's email)

Kate White
Black & White Communications
Haddington Farm
1007 Prince of Whales
Ottawa, Ontario K1S 3B6
613 225 8228 (T)
613 225 0054 (F)
kate@magma.ca

Michel Slivitzky
1440, rang Notre-Dame
Saint-Raymond, Québec G3L 1N5
418 337 6947 (T)
418 337 6666 (F)
michel_slivitzky@inrs-eau.uquebec.ca

Appendix C – Workshop Agenda from Flood Mitigation Workshop

Flood Mitigation Workshop December 15-16th, 1999 in Hull, Québec

Workshop Agenda

Wednesday, December 15th, 1999

9:30 Welcome and Introductions
(Ian Burton, Chris Tucker, Self-Introductions of Expert Panel)

9:50 Presentation of First Order Draft, "Flood Damage Mitigation for Canada
(Ashij Kumar)

10:05 Round Table Discussion of First Order Draft

- Does it serve the requirements?
- What are its strengths and weaknesses?
- How might it be improved?

10:30 Coffee Break

10:45 Round Table Discussion of Paper Continues

12:00 Lunch

13:00 Break-Out Groups Discussion using the Nominal Group Technique:

- What are the core questions for assessing the effectiveness of past flood mitigation measures in Canada that still need to be asked?
- How do we make the link from knowledge of floods to actual changes in Canadian flood policy?
- What is the way ahead to provide input for future policy and action related to the mitigation of flood hazard in Canada?

15:00 Coffee Break

15:15 Continue Break Out Group Discussions

17:00 Adjournment of Day 1

Thursday, December 16th, 1999

9:00	Reports from Break-Out Groups and Discussion Period
10:30	Coffee Break
10:45	Continuation of Discussion Items, Summarization of Salient Points, and Future Steps of Expert Panel
12:30	Closing Remarks / Lunch
15:00	Adjournment of Day 2

Appendix D – References

American Society of Civil Engineers (1998) "Report Card for America's Infrastructure" [WWW document available at, http://www.asce.org/govnpub/start.html].

Anderson, G. (1999) "Disaster management strategies to save lives and reduce losses" Proceedings from the First annual Catastrophic Loss Reduction Symposium, Building Resilient Communities, Toronto Sheraton Centre, November 15, 1999.

Andrews, J. (ed.) (1993) "Flooding: Canada Water Book" Ottawa: Ministry of Supply and Services Canada.

Booth, L. and F. Quinn (1995) "Twenty-Five Years of the Canada Water Act" *Canada Water Resources Journal*, 20(2): 65-90.

Boyd D. (1997) "Saguenay Storm Applied to The Grand River Watershed" Water News, *Canadian Water Resources Association*, 16(1A) Anniversary Issue 1997.

Boyd, D. (1996, December) "Saguenay Flood Can it Happen Here?" *Grand Actions News Letter*, 1, Grand River Conservation Authority 1996.

Brown, D.W., S.M.A. Moin and M.L. Nicolson (1997) "A comparison of flooding in Michigan and Ontario: 'Soft' data to support 'soft' water management approaches" *Canadian Water Resources Journal*, 22(2): 125-139.

Buckland, J. and M. Rahman (1999) "Community-based Disaster management during the 1997 Red River Flood in Canada" *Disasters*, 23(2):174-191.

Cardy, W.F.G. (1976) "Flood Management in New Brunswick" *Canadian Water Resources Journal*, 1(1): 40-46.

CSTGB (Commission scientifique et technique sur la gestion des barrages) (1997) "Rapport: Commission scientifique et technique sur la gestion des barrages" Québec, Janvier 1997, 241 pp. + annexes [Report translated to English by CDSA - ACSB (Canadian Dam Safety Association - Association Canadienne pour la Sécurité des Barrages)].

Day, J.C. (1999) "Planning for flood in the Lower Fraser Basin, British Columbia: Toward an integrated approach?" *Environments*, 27(1): 49-66.

de Loë, R. (Forthcoming) "Floodplain Management in Canada: Overview and Prospects" *Canadian Geographer*.

de Loë, R. and D. Wojtanowski (Forthcoming) "Associated Benefits and Costs of the Canadian Flood Damage Reduction Program" *Applied Geographer*.

de Loë, R. and D. Shrubsole (1998) "An Assessment of a Proposed Floodplain Management Evaluation Methodology" *Report prepared for* Environmental Adaptation Research Group, Institute for Environmental Studies, University of Toronto.

de Loë, R. and B. Mitchell (1995) "A Methodology to Evaluate the Flood Damage Reduction Program" *Report prepared for* Water and Habitat Conservation Branch, Canadian Wildlife Service, Environment Canada, Ottawa, Ontario.

Doughty-Davies, J.H. (1976) "Floodplain Management in British Columbia" *Canadian Water Resources Journal*, 1(1): 67-74.

Emergency Preparedness Canada (2000) *Data from* Emergency Preparedness Canada Database on flood costs" October 2000.

Emergency Preparedness Canada (1999) "Federal Disaster Financial Assistance Arrangements (DFAA)" [WWW document available at, http://www.epc-pcc.gc.ca/publicinfo/fact_sheets/disas_fin_ass.html].

Environment Canada (1983) "Canada Water Year Book 1981-1982" Ottawa: Ministry of Supply and Services Canada.

Epp, D., C.E. Haque, and R.C. Annis (eds.) (1998) "Emergency Preparedness and First Nation Communities in Manitoba" *Report prepared for* Emergency Preparedness Canada. [pdf document available at, http://www.epc-pcc.gc.ca/research/down/Firstnation_e.pdf]

Fisheries and Environment Canada (1976) "Canada Water Year Book 1976" Ottawa: Ministry of Supply and Services Canada.

Forget, S., B. Robert and J. Rousselle (1999) "The Effectiveness of Flood Damage Reduction Measures in the Montreal Region" *Report prepared for* Environmental Adaptation Research Group, Institute for Environmental Studies, University of Toronto.
[WWW document available at, http://www.epc-pcc.gc.ca/research/scie_tech/ef_floodmg/fdrp_mont/].

Giles, W. (1976) "Floodplain Policies in Ontario" *Canadian Water Resources Journal*, 1(1): 15-20.

Grescoe, T. (1997) "After the Deluge" *Canadian Geographic*, 117(2): 28-40.

Halliday, R.A. (2001, December 18) Comments by R.A. Halliday on "Assessment of the Flood Hazard and Mitigative Measures in Canada" *Personal Communication*.

Handmer, J.W. (1980) "Flood Hazard Maps as Public Information: An assessment within the context of the Canadian Flood Damage Reduction Program" *Canadian Water Resources Journal*, 5(4): 82-108.

Haque, C.E. (Forthcoming) "Risk Assessment, Emergency Preparedness and Response to Hazards: The Case of the 1997 Red River Valley Flood, Canada" *Natural Hazards*.

Haque, C.E. and D. Epp (1998) "Sioux Valley First Nation" in D., C.E. Haque, and R.C. Annis (eds.), *Emergency Preparedness and First Nation Communities in Manitoba,* Report prepared for Emergency Preparedness Canada. [pdf document available at, http://www.epc-pcc.gc.ca/research/down/Firstnation_e.pdf]

Hooper, B.P. and J.A. Duggin (1996) "Ecological riverine floodplain zoning: Its application to rural floodplain management in the Murray-Darling Basin" *Land Use Policy*, 13(2): 87-99.

Hunt, C. (1999) "A Twenty-First Century Approach to Managing Floods" *Environments*, 27(1): 97-114.

Insurance Bureau of Canada (1999) "A National Mitigation Strategy: Protecting Canadians from severe weather and earthquakes" [WWW document available at, http://www.ibc.ca/English/articles/nat_mit_strategy.htm].

International Joint Commission (1997) "Red River Flooding: Short-Term Measures" Ottawa/Washington: International Joint Commission. [WWW document available at, http://www.ijc.org/boards/rrb/taskforce.html].

Kreutzwiser, R.D. (1988) "Municipal Land Use Regulation and the Great Lakes Shoreline Hazard in Ontario" *Journal of Great Lakes Research*, 14(2): 142-147.

La Forest, G.V. (1969) "Natural Resources and Public Property under the Canadian Constitution" University of Toronto Press.

Maniate, P.M. and D.C. Carter (1973) "The Basics of Benefit-Cost Analysis" Ottawa: Policy and Planning Directorate, Environment Canada.

McKay, J. (1996) "Canadian Perceptions of Hydrometeorological Extreme Events" *Report prepared for* Atmospheric Environment Service, Environment Canada.

Miller, J. (1997) "Floods: People at Risk, Strategies for Preservation" New York: United Nations.

Millerd, F.W., C.M. Dufournaud and K.A. Schaefer (1994) "Canada-Ontario Flood Damage Reduction Program-Case Studies" *Canadian Water Resources Journal*, 19(1): 17-26.

Ministry of Natural Resources (1977) "A Discussion Paper on Floodplain Management Alternatives in Ontario" Ontario: Queen's Printer.

Mitchell, B. and D. Shrubsole (1992) "Ontario Conservation Authorities: Myth and Reality" Waterloo: Department of Geography Publication Series, Number 35.

Morris-Oswald, T., S. Simonovic and J. Sinclair (1998) "Efforts in Flood Damage Reduction in the Red River Basin: Practical Considerations" *Report prepared for* Environmental Adaptation Research Group, Institute for Environmental Studies, University of Toronto.

Myers, R.L., N. Stein and J. Fishleder (1999) "Coordinated Resource Management: Planning in the Alhambra Creek Watershed" *Geo Infor Systems*, 9(2): 30-35.

Natural Hazards Center, University of Colorado and Disaster Research Institute, University of Manitoba (1999) "An Assessment of Recovery Assistance Provided after the 1997 Floods in the Red River Basin: Impacts on Basin-Wide Resilience" *report submitted to*, International Red River Basin Task Force International Joint Commission. [pdf document available at, http://www.ijc.org/boards/rrbtf.html].

NCDEM (North Carolina Division of Emergency Management) (1998) "Tools and Techniques for Mitigating the Effects of natural Hazards" Division of Emergency Management, Mitigation Section, Raleigh, N.C.

Park, J. (1997) "Preliminary Review of the Environmental Impacts of the 1997 Red River Flood" *Report prepared for* Atmospheric Environment Service, Environment Canada.

Pearse, P.H. and F. Quinn (1996) "Recent Development in Federal Water Policy: One Step Forward, Two Steps Back" *Canadian Water Resources Journal*, 21(4): 329-340.

PETRIS (1999) A GIS-based Hydrological/Hydraulic Approach for Floodplain Mapping. [WWW document available at, http://www.petris.com/news/documents/wpHydrologic.shtml].

Platt, R.H. (1999) "From Changing Control to Flood Insurance: Changing Approaches to Floods in the United States" *Environments*, 27(1): 67-68.

Rahman, M.M. (1998) "Roseau River Anishinabe First Nations" in D. Epp, C.E. Haque, and R.C. Annis (eds.), *Emergency Preparedness and First Nation Communities in Manitoba,* Report prepared for Emergency Preparedness Canada. [pdf document available at, http://www.epc-pcc.gc.ca/research/down/Firstnation_e.pdf]

Roy, E., J. Rousselle and J. Lacroix (1997) "Flood Damage Reduction Program in Québec Case of the Chaudière River. École Polytechnique de Montréal" *Report*

prepared for Environmental Adaptation Research Group, Institute for Environmental Studies, University of Toronto.

Schaefer, K.A. (1990) "The effect of foodplain designation/regulations on residential property values: a case study in North York, Ontario" *Canadian Water Resources Journal*, 15(4): 319-332.

Schaefer, K.A. (1989) "Floodplain Regulations and Property Values: Canadian Perspectives and Experiences" in *Partnerships: Effective Flood Hazard Management*. Proceedings of the Thirteenth Annual Conference of the State Floodplain Managers, Scottsdale, Arizona. May 22-27, 1989.

Schildgen, B. (1999) "Unnatural Disasters" *Sierra*, 84(3): 48-57.

Shrubsole, D. (2000) "Flood Management in Canada at the Crossroads" *Report prepared for* Institute for Catastrophic Loss Reduction, ICLR Research Paper Series No. 5. Toronto, Ontario.

Shrubsole, D., V.J. Hammond, R. Kreutzwiser and I. Woodley (1997) "Assessing Floodplain Regulation in Glen Williams, Ontario, Canada" *Journal of Environmental Management*, 50(3): 301-320.

Shrubsole, D. (1996) "Ontario Conservation Authorities: Principles, Practice and Challenges 50 Years Later" *Applied Geography*, 16(4): 319-335.

Shrubsole, D. and J. Scherer (1996) "Floodplain Regulations and the Perceptions of the Real Estate Sector: The Cases of Brantford and Cambridge, Ontario, Canada" *Geoforum*, 27(4): 509-525.

Shrubsole, D., V.J. Hammond and M. Green (1995) "Floodplain Management in London, Ontario, Canada: Assessing Implementation of Section 28 of the Conservation Authorities Act" *Environmental Management*, 19(5): 703-717.

Smith, A.F., D. Boyd, and B. Veale (2000, December 8) *Personal Communication*.

Sutter II, G.W. (1993) "Ecological Risk Assessment" Boca Raton: Lewis Publishers.

Tversky, A. and D. Kahnemann (1982) "Judgment under uncertainty: Heuristics and biases" New York: Cambridge University Press.

Tiner, T. (1998) "Opening the flood gates" *Seasons: Ontario's Nature and Environment Magazine*, 38(4): 20-23, 40-41.

Veale, B.J., E. Pringle, R. Tufgar, M. Puddister, J. Parish, B. Mitchell, D. Shrubsole, J. Bauer, J. Anderson, J. Bruce, J. Imhof, S. Hilts, T. Kurtz, M. Dorfman and M. Coutts (1997) "Watershed Management in Ontario: Two Steps Forward – One

Step Back?" in J.P. Bruce (ed.), *A Watershed Approach to Conservation in Canada*. Soil and Water Conservation Society.

Watt, W.E. and J.D. Paine (1992) "Flood risk mapping in Canada: 1. Uncertainty considerations" *Canadian Water Resources Journal*, 17(2): 129-138.

Watt, W.E. (1995) "The National Flood Damage Reduction Program: 1976-1995" *Canadian Water Resources Journal*, 20: 237-247.

Weiss, G. (1987) "Benefits of Flood Hazard Mapping: The Case of Pilot Butte Creek in Regina, Saskatchewan" Report WPM-WNR-1888-01. Environment Canada, Regina.

Wile, A. and M. Ellis (2001, January 4) "Canada's Farm Income Safety Nets: Flood Protection" Report prepared by Crop Insurance and Companion Programs, Farm Financial Programs Branch, Agriculture and Agri-Food Canada. *Personal Communication.*